# Evaluating the City of Toronto's Home Energy Loan Program

An investigation into the environmental and economic impacts of the applied energy efficiency retrofits

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## Abstract

This research looks at Toronto's Home Energy Loan Program (HELP) and evaluates the outcomes of this program. HELP is a pilot municipal program that offers a low interest loan to homeowners who are willing to undertake energy efficiency improvements. This program is unique in Toronto in that it is the first and only program that finances energy efficiency through the local improvement charges and allows repaying the loan through an additional charge on the property tax bill.

This research aims to evaluate the HELP program in terms of its energy saving and GHG reduction achievements and examines the role of the program in bridging the so-called energy efficiency gap. To get a better and more accurate understanding of the program's performance, two other energy efficiency programs, namely R.E.E.P and Enbridge HEC were introduced and compared with HELP. More specifically, the paper conducts:

- An impact evaluation, in which the program is evaluated in terms of its natural gas saving, electricity saving, GHG reduction, number of improvements, and Enbridge scores increase.
- An efficiency evaluation, in which a cost-benefit analysis is conducted and the specific NPV, IRR, ROI, total costs, and total benefits of 31 of the HELP projects are calculated. The efficiency evaluation examines the cost-effectiveness of investing in energy efficiency retrofitting through HELP from the homeowners' point of view.

The impact evaluation shows that the HELP program wasn't able to encourage homeowners to undertake deeper energy efficiency improvements. It also indicates no

significant energy saving and GHG reduction achievements for the program, when compared to the other introduced programs.

The efficiency evaluation conducted in this research proves that around 71% of the HELP projects were considered cost-effective from the homeowners' perspective, but had long payback periods. The research finally acknowledges the role of HELP in bridging the barrier of high upfront costs by assisting homeowners who were initially interested in investing in energy efficiency retrofitting. However, the study found no evidence that HELP played a role in promoting energy efficiency retrofitting as a pro-environmental behaviour among homeowners who wouldn't consider energy retrofitting without the assistance of HELP.

# Foreword

I entered the Master of Environmental Studies (MES) program with a deep passion for urban planning and sustainability. As I was raised in Tehran, a city with high air pollutants, I was drawn to the scope of GHG reduction, urban sustainability, and community energy planning.

This Major Research Paper (MRP) is aligned with my area of concentration: Urban planning for sustainable cities, and mainly satisfies the second and the third components of my Plan of Study (POS). The second component of my POS is 'Climate Change Mitigation and Greenhouse Gas (GHG) Reduction' that focuses on policy-making and program design for reducing the level of GHG emissions. As the number of old residential dwellings is significantly higher than the new buildings in Toronto, and upgrading the energy performance of old dwellings is more challenging, I looked forward to learn more about the daunting tasks of program design and policy-making for promoting energy efficiency among homeowners. In my third component 'Energy Economics and The Anthropology of Energy' I expressed my desire to explore the interdisciplinary field of environmental studies with an emphasis on energy economics and the anthropology of energy.  In this MRP, I tried to look at the concept of energy efficiency through the lens of anthropology and explored the barriers and burdens homeowners face to acquire the pro-environmental behaviour.

I decided to work on evaluating the Home Energy Loan Program (HELP) for my major research paper, as I found that this pilot program has drawn the attention of many other municipalities across Canada. Also, because of the positive reputation of the similar programs in the United States, I could see a high potential for this program to play an effective role in bridging the existing energy efficiency gap in Toronto.

To conduct this research, I found a great opportunity to use the knowledge I developed through my MES course work, my internships, the conferences I attended as a graduate student, and the various workshops held by the Faculty of the Environmental Studies. Conducting and writing this research familiarized me with the planning tools and program evaluation methods and enabled me to apply the theories I learned during the MES program in practice.

## Acronyms

| | |
|---|---|
| **BTU** | British Thermal Unit |
| **CBSM** | Community Based Social Marketing |
| **CCM** | Cumulative Cubic Meters |
| **CDIAC** | Carbon Dioxide Information Analysis Centre |
| **CMHC** | Canada Mortgage and Housing Corporation |
| **CO2** | Carbon Dioxide |
| **CVA** | Current Value Assessment |
| **egCo2** | Estimated Grams of Carbon Dioxide |
| **EIA** | U.S. Energy Information Administration |
| **GDP** | Gross Domestic Product |
| **GHG** | Greenhouse Gas |
| **GTA** | Greater Toronto Area |
| **HAP** | Home Assistance Program |
| **HEC** | Home Energy Conservation program |
| **HELP** | Home Energy Loan Program |
| **IEA** | International Energy Agency |
| **IESO** | Independent Electricity System Operator |
| **IRR** | Investment Rate of Return |
| **Kg** | Kilogram |
| **Kj** | Kilojoule |
| **kWh** | Kilowatt hour |
| **LDC** | Local Distributing Company |
| **LEAP** | Low Income Energy Assistance Program |
| **LIC** | Local Improvement Charge |
| **M3** | Cubic Meter |
| **MAH** | Ministry of Municipal Affairs and Housing |
| **MOE** | Ministry of Energy |
| **NG** | Natural Gas |
| **NPV** | Net Present Value |
| **NRCan** | Natural Resource Canada |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PACE** | Property Assessed Clean Energy program |
| **POA** | Property Owner Agreement |
| **RH** | Relative Humidity |
| **ROI** | Return on Investment |
| **SEE Action** | State and Local Energy Efficiency Action network |
| **StatCan** | Statistics Canada |
| **TOE** | Toronto Office of the Environment |
| **U.S. DOE** | U.S. Department of Energy |

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# Chapter 1: Introduction

## 1.1The importance of residential energy efficiency improvements

The 'climate of concern' is what we call today's era of air pollution, rising temperatures, shifting precipitation patterns, and more frequent extreme weather occurrences that threaten humans and other beings that inhabit the Earth. There is overwhelming evidence that human activities leading to the emission of Green House Gases (GHG) have negative consequences and directly or indirectly affect climate change (IPCC, 2014; McCarthy, 2012). The environmental impact of fossil fuel consumption and the derived GHG emissions require a transition to a non-carbon, or at least low-carbon, energy system. Similar to many jurisdictions, Ontario is taking a step towards this critical transition and has set out targets to reduce its GHG emissions to 15% below the 1990 levels by 2020, and 80% below the 1990 levels by 2050 (NRCan, 2014).

The residential sector is the third largest energy consuming sector in Canada. This sector emits 15% of the total GHG emissions related to secondary energy-use (Office of Energy Efficiency, 2011). About 80% of the total energy used in the residential sector is related to space heating and cooling, and around 20% of that energy is wasted due to the inefficiency of the buildings. Therefore, there is potential to reduce energy consumption and GHG emissions by improving the energy efficiency of residential buildings.

Energy efficiency and energy conservation both reduce energy consumption, but they are slightly different. Energy conservation is a behavioural change that leads to reduced energy consumption, whereas energy efficiency is based on a technological or equipment-related change that leads to lower energy usage while providing the same or better services. Energy conservation and energy efficiency are more economically feasible than replacing fossil fuels with renewables, considering the current levels of consumption and efficiency. Furthermore, as energy efficiency and conservation reduce energy demands, investing in these two areas will lead to a lower use of any kind of energy source, therefore reducing the long term costs of energy for energy end-use consumers. As Coley (2012) notes, "Often termed 'the silent renewable', energy efficiency, or conservation, is the most promising sustainable energy strategy in the short to medium term, offering the promise of large carbon savings for relatively little expenditure and little environmental impacts" (p.153).

The province of Ontario demonstrates and mandates a relatively high standard in energy efficiency for newly-constructed buildings. However, the majority of Ontario's housing stock is old and inefficient. Therefore, the potential exists to develop high energy and GHG savings in the existing building stock of Ontario.

Given the importance of the residential sector in reducing energy consumption and improving energy efficiency, numerous studies have attempted to identify methods for promoting energy efficiency in the residential sector. There is a consensus among many scholars regarding the existence of an energy efficiency gap, which is a gap between the technological and economic potential and the actual market behaviour (Wilson & Dowlatabadi, 2007, p. 171; See also Hirst & Brown, 1990; Jaffe & Stavins, 1994; Golove & Et, 1996;). To bridge the energy efficiency gap, governments tend to promote and support energy efficiency improvements by offering incentives, tax rebates, and low-interest loans to homeowners and/or residents who undertake energy efficiency retrofits.

One of the most recent energy efficiency programs that aims to break the financial barriers faced by homeowners seeking energy efficiency improvements is called Property Assessed Clean Energy (PACE). The program is based in Berkeley, California. PACE funding comes from the local municipality. The loan is attached to the property and is reflected on the property tax bill, which is repaid by the person who owns the property. This program is available to commercial buildings in 31 states in the U.S., and more than 51,000 homes have used residential PACE since 2008 (PaceNation, 2015). The PACE program finances energy efficiency retrofits and renewable energy installation.

In 2014, The City of Toronto used a similar program design format and piloted the Home Energy Loan Program (HELP). This program is unique in that it is the first program in Ontario that uses Local Improvement Charges to finance energy efficiency retrofitting. Unlike PACE, this program does not finance renewable energy installation.

This Major Research Paper aims to explore the barriers homeowners face when undertaking energy efficiency retrofits and examine the role of HELP in overcoming those barriers. The paper evaluates the Home Energy Loan Program through conducting impact and efficiency analyses.

I begin this paper with a high-level overview of the benefits and importance of energy efficiency on different scales. Then, I explain the concept of the energy efficiency gap and point out the causes and drivers of this phenomenon. Looking at building specific energy saving and GHG reduction data and comparing it with other programs (namely Enbridge HEC and R.E.E.P), I examine the role of HELP in bridging the energy efficiency gap and promoting deeper and more efficient improvements. By conducting a cost-benefit analysis, I demonstrate the cost benefit ratio of each HELP project and evaluate the program in terms of its cost effectiveness from the participants' perspective. Finally, I provide a brief list of recommendations to improve HELP's performance.

## 1.2 The Multiple Benefits of Energy Efficiency Improvements in the Residential Sector

Aside from energy saving, there are many benefits associated with energy efficiency improvements in the residential sector. The International Energy Agency (IEA) categorizes these benefits into the individual, sectoral, national, and international levels (IEA, 2008). In this paper, I will use the same organizing framework to explore the benefits of energy efficiency improvements in greater detail.

### 1.2.1 The Individual Level

*Health and wellbeing*: One key benefit of home energy efficiency improvement, as identified by the IEA (2008), is improving health and wellbeing. Despite the fact that we spend around 90% of our lives inside, there is little emphasis placed on indoor air quality and how it affects our health and wellbeing (Howden-Chapman, 2004). Energy efficiency upgrades increase thermal comfort by improving heating and cooling systems. Improved thermal comfort is of critical importance for groups, such as children and seniors, who are more prone to temperature-related illnesses. A study conducted by Rohles and Johnson (1972) indicated that the mean indoor temperature preferred by seniors is one-half degree higher than the average middle-aged adult (Rohles & Johnson, 1972). Therefore, improving the energy efficiency of older adults' homes is in compliance with keeping the heat in and making homes warmer. In addition, lack of thermal comfort can negatively affect older adults throughout the summer and in high-temperature areas. The decrease of sweat production with age makes lowering the body temperature more challenging and, therefore, increases the chance of heat stroke (Ahrentzen et al., 2015).

Relative Humidity (RH) is another air quality factor that impacts residents' health. Higher levels of RH usually foster allergens, mold, and dust-mites, while low levels of RH produce skin, nose, and throat dryness, increasing the risk of upper respiratory illnesses (Ahrentzen et al., 2015. p. 3). Ahrentzen et al.'s study on 74 units of a senior housing complexes indicated that with a 19% reduction in energy use and reduction of extreme indoor temperatures, residents' reported health measures related to quality of life, emotional distress, and sleep were significantly improved (Ahrentzen et al., 2015. p.11).

According to the International Energy Association (IEA), energy retrofits are associated with reduced symptoms of rheumatism and arthritis as well as fewer physical injuries. In addition, IEA argues that, when the impact of energy efficiency retrofits on occupants' health and wellbeing is considered, there is a benefit-cost ratio of 4:1. Health benefits represent about 75% of the benefits (OECD/IEA, 2014).

Lighting efficiency improvement is another home energy upgrade that can improve building occupants' health and wellbeing. Labour productivity and enhanced visual comfort are two benefits of lighting efficiency improvements (Mills & Rosenfeld, 1996). In office environments, improved lighting may also reduce headaches and fatigue, therefore improving overall wellbeing (Mills & Rosenfeld, 1996).

Howden-Chapman (2004), looks at the impact of home energy retrofitting on mitigating health inequalities. Their research provides strong evidence that poor-quality housing negatively affects our psychological wellbeing. Howden-Chapman argues that housing is a "psychological space", a "symbol of achieved status", and "a symbolic extension of self" (Howden-Chapman, 2014. p. 164). In this perspective, poor-quality housing may result in stress, pessimism, disappointment, and passivism (Howden-Chapman, 2014. P. 164).

*Accessible and Affordable Energy: Reduced Energy Bills with Equal or Greater Comfort:* The main motivator for many homeowners to retrofit their properties is reducing energy bills without compromising their comfort. Lower energy bills decrease living costs and increase homeowners' disposable income (IEA, 2008; IEA, 2014; NRCan, 2014). Furthermore, energy efficiency improvements and the resulted bill savings lower homeowners' sensitivity about rapid energy price fluctuations (NRCan, 2014). According to NRCan (2014), a study conducted in 2011 indicated that the residential sector saved more than $20 billion and businesses more than $14 billion in energy costs from all energy efficiency improvements since 1990 (NRCan, 2014. p. 5).

Energy affordability and accessibility is of critical importance, specifically to low-income groups and developing countries (IEA, 2008). Additionally, as homeowners who are willing to undertake energy efficiency improvements become eligible for government funding, tax rebates, and financial incentives in many areas of Canada and other countries, retrofitting existing homes makes more economic sense.

*Increased Asset Value:* There is not enough peer-reviewed research about the impact of home energy efficiency improvements on the marketability and resale value of retrofitted homes. However, the U.S Department of Energy claims that when home values were decreasing in the United States, investing in energy efficiency boosted home resale values and increased the likelihood of selling homes (U.S DOE, 2015). A recent study by Kahn and Kak (2014) supports this statement. Kahn and Kak (2014) evaluated the impact of energy efficiency green labeling on the value of homes in the marketplace. As stated in their article, a highly efficient home with an "A" grade in terms of energy efficiency sells for a 10% price premium in the Netherlands (Kahn & Kak, 2014). Their study on 4321 California green labelled homes indicated that the Energy Star rating increased the resale value of homes by 4.7% (Kahn & Kak, 2014. p.32). It is worth mentioning that their study shows that factors such as location, environmental ideology, climatic conditions, and electricity prices impact the marketability of green homes. With the most conservative estimate, an average energy-certified dwelling can be sold for $8400 more than a non-labeled home in California (Kahn & Kak, 2014).

*Los Angeles Times* supports this assumption by elaborating on a research project by a non-profit institute called the Earth Advantage Institute. According to their research, new homes that had a sustainability and/or energy efficiency certificate were sold for 8% more than non-certified homes in the six-county Portland metropolitan area (LA Times, 2011). The same research shows that sustainability and/or energy efficiency certification increased the sale value of existing homes by 30% (LA Times, 2011).

### 1.1.2 The Sectoral Level

The benefits of energy efficiency improvements are not limited to residential sectors. Energy efficiency improvements benefit industrial and commercial properties by lowering their energy bills, increasing their property values, and reducing local pollution. However, as the emphasis of this research is placed on the residential sector, I will not explore the sectoral benefits of energy efficiency improvements in great detail. It is sufficient to note that, for energy providers and energy infrastructure services, energy efficiency improvements result in lower energy demand and, therefore, better energy services with lower operating costs (IEA, 2008). With high energy demand, improved energy generation capacity and infrastructure would be required to deliver energy to all economic sectors. As new energy supply infrastructure is extremely costly, time-consuming, and challenging for governments and utilities, improving energy efficiency on both the supply and end-use sides is more feasible (NRCan, 2014).

### 1.2.3 The National Level

*Job Creation*: One of the most important and most cited benefits of energy efficiency improvement is its positive impact on the job market and employment opportunities. According to Blyth et al. (2014), energy efficiency investments are more labour intensive than the fossil fuel industry (Blyth et al., 2014). Their study suggests that the average positive effect of energy efficiency investments on jobs is 0.80 job/gWh, while this number is about 0.15 job/gWh for coal and 0.12 job/gWh for gas (Blyth et al., 2014. p.10). As the demand for energy efficient products and energy efficiency upgrades increases, the demand for a range of skills and expertise for production, design, assessment, and implementation also increases. The increased demand boosts the economy and increases employment without using more natural resources. The International Energy Agency (2014) also argues that there is a high potential of energy efficiency investment to positively impact the job market. Accordingly, there is potential for energy efficiency improvements to create a range of 8-27 jobs per 1 million Euros investment in energy efficiency (OECD/IEA, 2014). Of course, it is important to note that the literature is mainly focused on Europe as an area of study, and these numbers may slightly or significantly differ in the Canadian context.

*The Macroeconomic Effect:* Large scale energy efficiency improvements can positively affect the Gross Domestic Product (GDP). The International Energy Agency suggests that wide implementation of energy efficiency policies can boost economic growth from 0.25% to 1.1% per year (OECS/IEA, 2014). Indeed, the economy can benefit from reduced energy demands and with the associated cost savings by reducing public expenditures and improving the public budgetary position (OECD/IEA, 2014; IEA, 2008). In addition, meeting national GHG reduction targets, providing a better and cleaner living environment, saving and protecting natural resources, and contributing to climate change mitigation are all important benefits of energy efficiency that are not limited to a specific category.

### 1.2.4 The International Level

This research does not elaborate on the international impact of energy efficiency improvements. The main focus of this research is on the environmental and economic impact of residential energy efficiency improvements, particularly small scale improvements at the individual and municipal levels. Hence, it suffices to say that energy saving, GHG reduction, energy price moderation, natural resource management, energy security and accessibility are all benefits of energy efficiency that are also critical on the international scale. As the high level of GHG emissions is directly linked to climate change, GHG reduction is an international and multidimensional problem. One important aspect of GHG emissions and climate change that clearly proves the international scope of energy efficiency is the fact that developing and poor countries are more vulnerable to natural disasters and the extremes of climate variability (Mirza, 2003). Climate change increases the frequency and severity of extreme weather conditions (Mirza, 2003). Looking at the countries ranked in terms of GHG emission, not many of these developing or poor countries make the list of the countries with the highest GHG emissions. The opposite can be said of more developed nations. In fact, the United States and Canada are two of the top GHG emitter countries (CDIAC, 2011). Thus, there is a high potential for these countries to reduce their GHG emissions and take a major steps towards climate change mitigation by investing in energy efficiency.

### 1.3 Conceptual Framework: The Energy Efficiency Gap

"[The] ground is littered with $20 bills that energy consumers have failed to pick up" (Allcott & Greenstone, 2012. p. 4).

There is a large body of literature dedicated to the existence of a gap between the technological and economic potential of energy efficiency and actual market behaviour. At the crux of the debate surrounding the energy efficiency gap is a critical question: Why is the concept of energy efficiency not widely applied, despite its technological feasibility and cost-effectiveness?

Jaffe and Stavins (1994) try to identify the main market barriers that hinder wide use of energy efficiency technologies and investigate the role of government intervention and public policy in narrowing the energy efficiency gap. Accordingly, the energy efficiency gap is associated with the paradox regarding gradual diffusion of the so-called cost-effective energy efficiency technologies (Jaffe & Stavins, 1994.p. 804). They argue that, similar to other economically superior technologies, the diffusion of energy efficiency technologies is gradual (Jaffe & Stavins, 1994). In the case of energy efficiency, however, there is a high potential for government intervention to narrow the gap between the observed rate of diffusion and the optimal rate, in which the wide application of energy efficiency improvements can be achieved (Jaffe & Stavins, 1994).

Typically, there are four phases for a technological change or a new process to take place: invention, innovation, diffusion, and product use (Jaffe et al., 2004). The second step is where the invention is commercialized and introduced to the market. The third phase, where gradual diffusion takes place, is where the market (individuals, firms, or customers) adopts the new technological change and decides on the level of investment and the intensity of using the new product or process (Jaffe et al., 2014). The energy efficiency gap can be seen in the third and last step of a technological change. Despite the economic and technological potential of energy efficiency, investments in these technologies are lower than desired, the diffusion pace is slow, and the application of energy efficiency improvements in most cities, including Toronto, is far from prevalent.

Golove and Eto (1996) argue that the energy efficiency gap reflects two distinct phenomena. First, a consistent behaviour towards assuming an excessively high discount rate for energy efficiency compared to equivalent investments and second, underinvestment in energy efficiency at market prices for energy versus underinvestment in energy efficiency because of mispriced energy (relatively low price of energy), negative environmental externalities (refer to chapter 3), and regulatory failure (Golovo & Eto, 1996.p.8).

**1.4 Government Intervention on Home Energy Efficiency Retrofits**

Governments can influence the diffusion rate of energy efficiency technologies by means of the conventional command-and-control regulatory policies or by using incentive-based economic instruments (Jaffe & Stavins, 1994). Stern (1999) found that larger financial incentives often result in a higher level of participation (Stern, 1999 cited in Hoicka et al, 2014). Looking at Stern's study, Hoicka et al. state that the size of the incentive had a stronger effect on participation in the second step (making improvements) than the first (signing up for an evaluation) where an evaluation was required prior to making improvements for which an incentive was given (Hoicka et al., 2014, p. 595). According to Stern et al. (1986), “Once people receive the energy audit, an incentive as large as 93% can generate almost certain action” (p. 471). Large incentives don’t have a great impact on encouraging homeowners to take the first step and participate in an energy efficiency program. Stern (1999) also argues that loans seem to be more attractive and more effective than financial rewards.

As Hoicka et al. (2014) assert:

> “the effectiveness of a financial reward will in part depend on how well negative contextual influences are minimized, such as the ease with which it is collected. For example, programs that employed a visit by a professional home energy advisor as the main intervention yielded lower participation rates than the programs that employed a take-home shopping-list.” (p. 595)

Gamtessa (2013) argues that as the cost of retrofit has a negative impact on retrofit investments, targeting the low-income homeowners and increasing the amount of incentive can increase the effectiveness of the program, rather than offering the same amount of incentive to all income groups (p. 156).

### 1.5 Research Purpose and Research Question

My research aims to evaluate the pilot Home Energy Loan Program and understand the effectiveness of the program in reducing GHG emissions and energy consumption. The main research questions of this Major Research Paper are:

1) Does HELP meet its initial target after the pilot period?
2) To what extent is HELP cost-effective from a homeowners' perspective?
3) What is the magnitude of saved energy and reduced GHG emissions?
4) Did HELP encourage homeowners to do more and deeper energy efficiency improvements?
5) How effective is HELP in bridging the energy efficiency gap?

## Chapter 2: Methodology

### 2.1 Program Evaluation as the methodological framework

"Evaluation is not an end unto itself but an effective tool for supporting the adoption, continuation, and expansion of energy efficiency programs, and thus the efficient use of energy (The State and Local Energy Efficiency Action, 2012.p. XIV)".

The methodological framework of this research is program evaluation. Program evaluation primarily focuses on measuring the success of the program in meeting its objectives, identifying its limitations and deficiencies, and exploring methods and strategies to improve the effectiveness of the program (Pal, 2010). Michael Patton (2008) defines program evaluation as "the systematic collection of information about the activities, characteristics, and results of programs to make judgments about the program, improve or further develop program effectiveness, inform decisions about future programming, and/or increase understanding" (p. 39). Weiss defines evaluation as "the systematic assessment of the operations and/or the outcomes of a program or policy, compared to a set of implicit or explicit standards, as a means of contributing to the improvement of the program" (Weiss, 1998; cited in Pal, 2010, p.308). According to Mark et al (2000), "Evaluation assists *sensemaking* about policies and programs through the conduct of systematic inquiry that describes and explains the policies' and programs' operations, effects, justifications, betterment, and social implications" (p. 3). Mark et al. (2008) believe the ultimate goal of policy and program evaluation is "social betterment", which involves the reduction of social problems and improvement of social conditions.

The core categories of program evaluation, as identified by Pal (2010), are: 1) process evaluation in which program design, structure, and activities are evaluated; 2) impact evaluation where the program outcome is evaluated; 3) efficiency evaluation that conducts the cost-benefit analysis and understands the ratio of the costs and benefits of the program (Pal, 2010, p. 310).

Mark et al. (2000) also provide a framework for the evaluation practice that translates the ultimate goal of social betterment into the four main purposes of designing and planning policies or program evaluations. These four main purposes, as stated by Mark et al. (2000), are:

1. Assessment of merit and worth: evaluating the value of the program
2. Program and organizational improvement: gathering information to modify, improve, or enhance the program

3. Oversight and compliance: to understand if the program is in compliance with upper level rules, regulations, and other policies.
4. Knowledge development: to test and assess scholarly theories and research hypothesis about social mechanisms

This research mainly focuses on conducting an impact evaluation and an efficiency evaluation on the Home Energy Loan Program. Considering the purposes stated above, the program is evaluated by looking at the participation rates, energy saving and GHG reduction outcomes, and cost implications. Having the second purpose in mind, this paper aims to learn the weaknesses and deficiencies of the program and identifies methods to improve those areas by providing solutions and recommendations. This research also attempts to offer a bigger picture by investigating the role of this program in meeting Toronto's GHG reduction target and analyzing whether the program meets its own initial target. Finally, given the emphasis of the academic literature on the existence of the energy efficiency gap, the paper studies the role of offering a low-interest LIC-based loan in bridging this gap and achieving the optimal level of energy efficiency in the residential sector of the City of Toronto.

### 2.1.1 Impact Evaluation

Impact evaluation is a practice of evaluating the outcome of the program to determine whether the program meets its ultimate objectives and/or has a considerable positive impact on an issue that can be increased by scaling up the program. Conducting an impact evaluation is necessary for pilot programs, like HELP, that are scheduled to be scaled up.

Energy efficiency program impact evaluation involves measuring and evaluating the energy benefits (energy saving) and non-energy benefits such as health impacts, job creation, energy security, water savings, and local economic development (SEE Action, 2012).

This impact evaluation was conducted according to the impacts evaluation process guidelines provided by the State and Local Energy Efficiency Action (2012). Figure 1 illustrates the impact evaluation process completed for this research.

**Energy Efficiency Program Impact Evaluation Process Steps**

1. Setting the evaluation objectives with regards to the program's ultimate objective
2. Selecting an impact evaluation savings, determining approach, and defining a baseline scenario
3. Determining energy savings
4. Determining non-energy benefits (NEBs)
5. Preparing a report of the evaluation findings and results

Figure 1: Retrieved from SEE Action, U.S Department of Energy, 2012

The evaluation objectives, as stated before, are to measure the effectiveness of HELP in bridging the energy efficiency gap, the effectiveness of HELP in encouraging homeowners to save more energy and undertake deeper improvements (compared to other programs), and the magnitude of saved energy and avoided GHG emissions. In order to select the baseline scenario, the State and Local Energy Efficiency Action network (SEE Action) suggests that the difference between the participants' energy consumption after participating in the program and the amount of energy those same participants would have used had they not been in the program during the same time period should be estimated. This baseline is called the counterfactual scenario (SEE Action, 2012). Instead of comparing estimated energy consumptions in the same time period, this research compares and calculates the actual energy consumption before and after completing the retrofit. The pre-retrofit consumption is the baseline scenario for this research. One limitation of this approach, however, is that energy consumption is highly dependent on the time of year, season, and the outdoor temperature. Therefore, energy savings calculated from comparing pre and post retrofit consumption may be influenced by other factors such as the outdoor temperature. To overcome this limitation, energy advisors use a specific software that assesses energy consumption before and after retrofitting in the same controlled context, eliminating the impact of external factors.

*Program Impact Evaluation Criteria*

The program impact evaluation aimed to evaluate the program in terms of the total and average natural gas savings, total and average electricity savings, and GHG emissions reduction levels.

*Electricity (kWh) and Natural Gas Savings (m3):*

The pre and post retrofit natural gas consumption of each project was provided by Natural Resources Canada (NRCan). Calculating both the median and the average natural gas saving of the 31 projects and comparing that with other programs (Mainly R.E.E.P and Enbridge), provided an understanding of the effectiveness of the program in terms of energy savings. The median and average of the pre and post retrofit electricity consumption, along with the average and median electricity savings, were also calculated. In some calculations, a statically meaningful difference between the median and the average was observed. In those circumstances, in order to ensure the accuracy of the analysis, outliers were excluded and the average and mean were recalculated. In some cases, using the median for the analysis and/or exclusion of the outlier were unavoidable. The program outcomes of R.E.E.P and Enbridge were also used for comparison. R.E.E.P data is published online and was retrieved from their online annual report, while the average natural gas saving, average number of improvements, and natural gas saving percentage per project were provided to the City of Toronto by Enbridge. No building-specific information was collected from R.E.E.P or Enbridge. R.E.E.P data was used to compare the total natural gas savings and the total electricity savings of HELP with those of R.E.E.P. Enbridge data was used to compare the average natural gas saving of HELP with that of Enbridge and also used for the sample comparative analysis.

*The Avoided Greenhouse Gas Emissions:*

Generally, the greenhouse gas (GHG) emissions of homes is not measured when undertaking energy efficiency retrofits. To measure the avoided GHG emissions of each building and calculate the total GHG reduction, this paper used the emission factors outlined in Table 1.

| Energy Source | Unit | Emission Factor |
|---|---|---|
| Natural Gas (m3) | gCo2e/m3 | 1890.63 |
| Electricity (KWh) | gCo2e/kWh | 104.5 |

Table 1: GHG emission factors

The National Inventory Report (1990-2009) Greenhouse Gas Sources and Sinks in Canada recommends using 100.86 as the emission factor for electricity calculations. As this emission factor does not reflect the GHG emissions of transmission and distribution, the Environment and Energy division of the City of Toronto suggested the emission factor of 104.5 for this calculation. The following formula was used to calculate an estimate of the avoided GHG emissions of each HELP project:

$$Avoided\ GHG\ from\ NG = NG\ consuption\ (m3) \times emission\ factor$$

$$Avoided\ GHG\ \ from\ Electricity = Electricity\ consumption\ (kWh) \times emission\ factor$$

The avoided GHG emissions were calculated in gCo2/m3 for natural gas and gCo2/kWh for electricity. To get a more understandable result, the results were converted to tonnes of GHG.

### 2.1.2: Program Efficiency Evaluation

Program efficiency evaluation looks at the cost at which the program can achieve the desired outcome. In other words, the efficiency evaluation of HELP aims to understand whether the program is adequately resourced to enable the achievement of the desired outcomes. The main two techniques that are typically used in efficiency evaluation are cost-effectiveness analysis and cost-benefit analysis (Pal, 2010). Cost-effectiveness analysis looks at the non-monetary outcomes of the program. Cost-benefit analysis studies the monetary outcomes of the program. Cost benefit analysis evaluates the economic worth of a project or investment by quantifying and comparing costs and benefits in monetary terms. This research conducted a cost-benefit analysis on all 31 HELP projects to see if investing in energy efficiency through HELP is economical from a homeowners' point of view. For this analysis, the project life time, NPV, IRR, ROI, total costs, and total benefits were calculated. The details of number, type, lifetime, and costs of the intended and undertaken retrofit activities were included in the HELP application files at Metro Hall. For projects with multiple improvements, the weighted factor and weighted lifetime of each improvement was calculated, and a weighted average project lifetime was estimated. The costs, benefits, and payback periods were calculated while considering the lifetime of each improvement.

*NPV, IRR, and ROI*

NPV is a method used in evaluating capital budgeting that calculates the value of an investment as the total present value of all cash inflows minus the cost of the investment (Smullen & Law, 2008, p.333). Where the NPV of cash inflows and outflows is equal, the interest rate is the Internal Rate of Return (IRR) (p. 258). Return On Investment, or ROI, is the annual amount of income from an investment expressed as a percentage of the original investment (p. 425). ROI is a performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. These metrics were calculated by means of an excel template provided by the finance department of the Environment and Energy Division of the City of Toronto.

*Costs and Benefits*

In order to calculate the costs and benefits, the cost of borrowing and administrative costs were added to the actual funding amount for each HELP project. Taking the project lifetime and natural gas and electricity cost savings amount into account, the total costs, benefits, and payback period of each project were calculated.

## 2.2 Research Scope and Sample Size

As of October 2015, a total of 320 applications were received. The City extended funding offers to 180 homeowners of the total number of applicants. At this point, there are 74 contracted projects with a capital commitment of $1.4 million (Office of the Environmental Commissioner of Ontario, 2015). There are 52 completed projects that went through the entire process and retrofitted their properties, and there are 22 more applications in progress (currently at the third step of the program). Although there are 52 completed projects, the energy consumption and cost saving data was available for only 31 of the projects. Electricity and natural gas consumption amount, electricity costs, and Enbridge scores are not directly calculated by the HELP team. This data is provided by energy advisors and Natural Resource Canada, and it was not yet prepared for all 52 projects. As a result, this paper focuses on a sample size of 31 available projects.

There was not enough data about the direct health impacts and macro-economic impacts (e.g. job creation) of HELP. However, in a separate analysis, the GHG emissions reduction and the cost and benefit ratio were also calculated and analyzed.

The collected data for this research is in the building scale. An excel sheet of detailed information about the energy consumption and cost implications of the 31 participating properties was received from the Environment and Energy Division of the City of Toronto. A large portion of the data that was provided by the Natural Resource Canada (NRCan) includes the type of house, year built, energy audit dates, pre and post retrofit natural gas consumption, pre and post retrofit electricity consumption, post retrofit natural gas and electricity costs, annual natural gas saving, and the annual electricity savings of each participating property (31 in total). I was given access to the actual HELP files and was able to collect information about the number and type of improvements, pre and post retrofit EnerGuide scores, cost breakdowns of improvements, funding amounts, incentive amounts, building-specific energy assessment reports, and the expected lifetime of improvements. In addition, an excel template was provided for conducting the cost-benefit analysis and calculating the Net Present Value (NPV), Internal Rate of Return (IRR), and Return On Investment (ROI) of each project. I calculated the total avoided greenhouse gas emissions by means of the emission factors of natural gas and electricity. The cost of gas before retrofitting, estimated cost of gas per unit, natural gas cost saving, cost of electricity per unit, electricity cost saving, and the estimated cost of electricity before undertaking the improvements are all calculated and explained in greater details in chapter 4.

Through the HELP team, I connected with the Enbridge Gas residential marketing program advisor, and I was able to get aggregate data of the total natural gas consumption and total and average natural gas saving of the program in 2014. The information about the 2013 program outcomes was available to the public and was retrieved from the Ontario Energy Board website. For a better and more accurate analysis, I requested and received an excel sheet of 31 random Enbridge HEC participants who undertook energy efficiency retrofits and received the Enbridge gas rebate, but didn't get a loan from HELP. This data sheet consisted of pre and post retrofit energy consumption, natural gas savings, and the number and type of improvements for each project. Given the significant difference in the geographical coverage of HELP and HEC, I asked that the random sampling only include properties that were located within the boundaries of the City of Toronto. A limitation of focusing on average natural gas savings, given by the Enbridge program advisor, is that 27 of the HELP homes also received an incentive from Enbridge. Those projects are not excluded from the total number of Enbridge participants and, therefore, are included in the average calculation. To assure accuracy, more detailed analysis was conducted on the building specific scale, and the 31 HELP projects were compared with the 31 Enbridge HEC projects that received the incentive but not through HELP.

The R.E.E.P Home Assistance Program is very different from the HELP program in nature and design. It has different objectives, serves a specific segment of the market, and is mainly focused on electricity savings. As a result, comparing this program with HELP is like comparing apples and oranges. The reason why this research looks into the structure and outcomes of this program is the different design and the grassroots base of this program. Looking at R.E.E.P and its achievements may offer important lessons for HELP to learn and can widen my perspective, as the researcher, to alternative and novel forms of energy efficiency program design.

## Chapter 3: Causes and drivers of the energy efficiency gap

Jaffe et al. (2004) categorize the main barriers to optimal energy efficiency investments into the two categories of market failures and non-market failures. They believe there are market barriers that hinder the diffusion of energy efficiency investments. However, these market barriers are not necessarily market failures. In this context, there are two key definitions:

> Market Barriers: *"Disincentives to the diffusion and/or use of a good, such as high costs or prices, which may or may not represent market failures" (Jaffe et al., 2004, p. 79).*
>
> Market Failure: *"The failure of private markets to provide certain goods at all or at the most desirable level, typically arising from a situation in which multiple parties benefit from a good without decreasing one another's benefits, and in which those who have paid for the good cannot prevent others from benefiting from it" (Jaffe et al., 2004, p. 79).*
>
> Externalities: *An economically significant effect of an activity, the consequences of which are borne (at least in part) by parties other than the party who engages in the activity, and which are not accounted for through trade (Jaffe et al., p.79).*

### 3.1 Market Failures

The main market failures identified by Jaffe et al. (2004) are lack of information, externalities (environmental, innovation, and adoption), principal-agent problems, 'artificially low' energy prices, and market barriers in energy supply. The principal-agent problem occurs when the energy efficiency decision-maker is not the person who pays the bills (Jaffe & Stavins, 1994). In this case, energy efficiency investment is expected to be made by a party who doesn't directly benefit and/or make any profit from the investment. In this chapter, I suffice with introducing the concept of externalities as forms of market failure, explain types of externalities that widen the energy efficiency gap, and point out non-market failure barriers that prevent the wide application of energy efficiency technologies.

### 3.1.1 Information and Innovation Externalities

Inadequate information is one of the most cited barriers to the wide application of energy efficiency improvements. Information may act as a source of market failure due to its important public goods attributes (Jaffe & Stavins, 1994). Although lack of enough information is a key barrier to investing in energy efficiency, as an investor there is little interest and inadequate economic profit in investing in the scope of information. Once information is given, there is little or no control over its diffusion among those who have paid, and it is difficult to restrict or limit the access of those who haven't paid (Jaffe & Stavins, 1994). When a homeowner invests in a new energy efficiency technology, the "application of the new technology" is useful information for the neighbours. Neighbours can wait and see the outcome of the investment along with the application and usefulness of the new technology. In this case, the act of adopting a new technology acts as a positive externality by providing information about the technology without being compensated (Jaffe & Stavins, 1994, p. 805). The positive externality, in this context, acts as a market failure (Jaffe & Stavins, 1994).

### 3.1.2 Environmental Externalities

As an environmental polluter imposes cost on others, there is little or no incentive for the polluter to reduce the costs (Jaffe et al., 2004). For instance, an inefficient electricity generator imposes costs on society by polluting the air and putting people's health and wellbeing at risk. Without the existence of effective policy tools, there is no motivation for the electricity generator company to decrease the level of pollution (Jaffe et al., 2004). Thus, pollution creates negative externalities. In this context, the negative externality acts as a market failure.

## 3.2 Non-Market-Failures

The debate around non-market-failure barriers that cause or widen the energy efficiency gap is mainly focused on explaining why observed behavior is indeed optimal from the point of view of individual energy users (Jaffe et al., 2004, p. 85). As the energy efficiency gap is known to be affected by consumers' social and behavioural patterns, the emphasis of the next section is placed on barriers to undertaking home energy efficiency improvements that homeowners face. Indeed, these barriers have a significant impact on widening the energy efficiency gap. The barriers are mainly non-market failures.

I have categorized the barriers to undertaking energy efficiency improvements into four groups: behavioural, economic, social, and structural. These are not discrete barriers. They overlap one another and must be studied in conjunction with each other. Therefore, in this paper the barriers, although categorized, become integrated and combined at some points.

### 3.2.1 Behavioural Barriers

When making decisions, there is a chance that individuals won't make a rational choice. In fact, there are many factors influencing individuals' decision-making processes that could hinder their ability to choose the most economically rational option. Making a decision about undertaking a home energy efficiency program can be highly influenced by individuals' behaviour, habits, and attitudes. For example, households might not be willing to lower the temperature in winters or undertake energy efficiency retrofits as they think these activities might compromise their comfort. In fact, although lowering the temperature and installing energy efficiency retrofits might be economically reasonable, decision-makers do not always decide according to economic rational. Another example of the role of behaviours and attitudes in decision-making is that when there are incremental or immediate costs, decision-making will become short-sighted. When all of the costs and benefits are in the future, individuals are more likely to be farsighted (Wilson & Dowlatabadi, 2007).

*Path Dependency*

Making decisions about undertaking energy efficiency retrofitting is primarily making a decision about changing the status quo. Individuals have different reactions towards change. Resistance is one of the common reactions to change. As retrofitting results in changing the home environment, at least for the period of the renovation, many individuals might resist undertaking such improvements. Furthermore, the time and effort that is needed to identify the available incentive programs, make choices, start the process, and complete it can hinder an individual's decision about participating in a retrofit program. As Stern et al. (1986) state, "consumers act as problem avoiders, doing nothing new unless they perceive a critical need and doing only what is necessary to make need recede from attention" (p.149). Reddy (1991) identifies a group of energy users as "The Helpless". Accordingly, the helpless are those who have both the knowledge and financial capacity to retrofit their house (Reddy, 1991). This group, however, are reluctant to invest their time and effort in starting the process. As it is much easier and more convenient for them to maintain the status quo, they decide not to undertake energy efficiency improvements and simply maintain their established patterns.

*Heterogeneity of Preferences*

Heterogeneity of Preferences may explain the reason behind the slow diffusion of energy efficient technologies (Gillingham & Palmer, 2013). As people are different in terms of their attitudes, values, norms, preferences, and decision-making processes, designing a program or a policy that targets all of the homeowners from different demographic backgrounds is a daunting, if not an impossible, task. Variables, such as residents' ages, homeownership, education levels, total household incomes, number of occupants, house sizes, and the age of the homes all affect energy consumption and participation in energy efficiency programs to a varying degree (Song, 2008). Homeowners, depending on their income or their age group, might favour different types of financial programs (loans versus incentives). Furthermore, an average cost-effective energy efficiency technology, that is affordable or cost effective for some individuals, might be unaffordable for others. In Jaffe et al.'s (1994) literature:

> If the relevant population is heterogeneous—with respect to variables such as the purchaser’s discount rate, the investment lifetime, the price of energy, the purchase price, and other costs— even a technology that looks very good for the average user will be unattractive for a portion of the population. (p. 86)

Indeed, heterogeneity of preferences is a challenging barrier to widening the application of energy efficiency technologies. Heterogeneity, in this context, acts as a double-edged sword. On one hand, it provides an opportunity for further research on the size and the nature of the energy gap among different segments of the market (Gillingham and Palmer, 2013). On the other hand, generalizability of the findings is a daunting task and, in many cases, a naïve assumption. It also indicates that there is not a one-size-fits-all solution for bridging the energy efficiency gap. It may also imply that more than one general loan or incentive program is required to promote energy efficiency among different communities and in different segments of the market.

### 3.2.2 Social Barriers

From a sociocultural perspective, energy consumption is a social construct. Individuals’ decision-making about energy consumption and energy efficiency retrofits is not individual in nature but is part of a complex relationship between social norms and relations, technologies, infrastructures, and institutions (Wilson & Dowlatabadi, 2007, p. 186).

Social norms and Social context can act as barriers or drivers to participate in energy efficiency programs. For instance, how homeowners/occupants perceive their home can positively or negatively affect their decision about undertaking energy efficiency improvements. Where home is considered as a shelter and only as a place to sleep, decision-making about energy efficiency investments could significantly differ from where home is considered as a centre of family, a centre of social life, a symbol of identity and social status, or a "shelter from the hectic pace of modern life" (Stieß et al., 2009, p.1822). Modernizing and renovating homes is not a routine. It is a decision that is made not more than once or twice in a lifetime and requires relatively large investments. Thus, the way people perceive their home significantly impacts their decision regarding whether to invest in refurbishing it.

*The Invisibility of Energy*

The importance of the invisibility of energy is threefold. First, as in most cases, energy supply and the process of generating power is not visible to the public. People are unaware or indifferent about the environmental, economic, and social impacts of energy consumption. Therefore, they have no or little interest in conserving energy and improving the energy efficiency of their homes. Second, energy-use and the quantity of energy consumption are not visible to energy consumers. People tend to overestimate the energy consumption of the visible appliances (such as televisions and washing machines), while the energy consumption and costs that are attributed to furnaces or water heaters are more likely to be underestimated (Stern, 1986). Furthermore, as energy consumption is not visible to consumers, and as they can't measure it themselves, they probably underestimate the role of conservation and energy efficiency in lowering their energy costs. Third, similar to energy supply and consumption, the outcome of energy efficiency improvements is relatively invisible, too. Although energy efficiency upgrades require investments of time and money, the outcome has little or no impact on the aesthetics and the appearance of the property. Stern (1986) argues that when making a decision, energy users are more concerned with intangibles, such as comfort and appearance, rather than financial benefits (Stern, 1986). Hence, because of the fact that efficiency improvements are invisible, homeowners might prefer to invest in more aesthetic changes to their property.

*Information*

As mentioned before, there is a large body of literature about the impact of information on extending the energy efficiency gap. The impact of information on decision-making about investing in energy efficiency is not limited to acting as a market failure. In this section, the multidimensional role of information is explored.

Hirst and Brown (1990) argue that the information gap is one of the main contributors to the energy efficiency gap. One aspect of information deficiency is that many residents are not aware of the level of inefficiency of their homes and the financial impacts of inefficiency. They are also unfamiliar with the existing incentives and retrofit programs and have difficulties identifying skilled and trustworthy contractors (Neme et al., 2011). As Stern (1986) argues, consumers are more likely to take effective economic actions when complete information about the financial costs and the potential energy savings are given. He states: “price responsiveness increases with the completeness of information” (Stern, 1986, p. 204). The scarcity of information about the technological and economic viability of energy efficiency improvement often results in overestimating the perceived risk of investment and, therefore, avoiding participation in the program (Hirst & Brown, 1990).

The trustworthiness and credibility of the information source is a crucial factor in individuals' decisions for undertaking energy efficiency improvements. For example, a message from a governmental organization would have a different impression compared to a message from a local distributor company that is known for gaining profits from improvements. The importance of the credibility of the information sources was assessed in a study in New York, where flyers were designed to inform residents about how they can save energy. Apartments that received flyers that were signed by the New York State Public Service Commission saved 7% on their next bill, while residents that received the exact same flyer signed by a Local Distributing Company (LDC) did not save anything (Stern, 1986).

Form of information delivery is another factor that can encourage or discourage participation in home energy efficiency retrofit programs. The way the information is communicated along with the quality and the level of that information significantly affects people's decision-making process. Decision makers tend to use a wide range of heuristics to digest the presented information. They favour familiar and simpler information and eliminate sources that they have a negative assumption about (Wilson & Dowlatabadi, 2007). The most effective information needs to be contextualized and socially embedded (Stieß & Dunkelberg, 2013, p. 252). Overall, personalized and simpler information seems to be more effective in drawing homeowners' attention to energy efficiency upgrades.

Type of information and the content of the conveyed messages are also critical for influencing homeowners' decision-making about retrofitting their homes. As Stieß et al. (2009) argue, the deficiency of available/perceived information results in a stronger influence of social networks on decisions. "Conflicting recommendations, prejudices and clichés as well as self-styled "advisors" in the social environment can make the planning and decision process a thorny task" (p. 1826 ).

### 3.2.3 Economic Barriers

*Uncertainty and Perceived Riskiness of energy efficiency*

To many decision-makers, investing in energy efficiency is highly associated with financial risks. Future costs and the financial benefits of energy efficiency are hardly predictable, while the incremental costs of energy efficiency are relatively high. Therefore, homeowners tend to find these types of investments risky and postpone or avoid investments (Reddy, 1991). In addition, in many cases homeowners are uncertain about the outcome of these improvements. They are not sure if the future energy savings would outweigh the incremental costs or if their investment would make sense from the economic point of view. Uncertainty about the outcome of energy efficiency can also lead homeowners who have decided to undertake retrofits to avoid choosing the most efficient upgrades (that are usually more costly). Instead, they may choose the less expensive and, therefore, less effective improvements.

*Limited Access to Capital and High Upfront Cost*

Often, the most efficient technologies have higher upfront costs, while inefficient technologies are less expensive. Therefore, despite knowing the net benefits of energy efficiency upgrades, homeowners might be reluctant or unable to pay the upfront costs. Additionally, many homeowners tend to associate higher discount rates in making a trade-off between higher upfront costs and lower operating costs (Hirst & Brown, 1990). In other words, homeowners overestimate the incremental cost and underestimate the cost savings of energy efficiency improvements. This barrier is known as the “payback gap”: “The difference between investment criteria for energy- efficiency versus energy-production investment (Hirst & Brown, 1990, p. 272).

*The Low and Aggregated Cost of Energy*

Overall, energy is not appropriately priced because energy prices do not reflect externalities (Hoicka et al., 2014). In fact, low energy prices negatively affect participation and any interest in improving energy efficiency, as the energy costs don’t attract the homeowners’ attention. Besides, as multiple energy uses are aggregated into one energy bill, consumers can hardly know how much they consume and, therefore, can’t measure the impact of the proposed efficiency upgrades. The following quote from Kempton and Montgomery (1982) clearly explains how aggregation of multiple energy use can hinder people from undertaking energy efficiency retrofits:

> Imagine a parallel situation for groceries: a store without prices on individual items, which presented only one total bill at the cash register. In such a store, the shopper would have to

estimate item price by weight or packaging, by experimenting with different purchasing patterns, or by using consumer bulletins based on average purchases. Although these cost estimation methods seem unbelievably crude for groceries, we show here that such methods are indeed used to estimate household energy use. (p. 271)

### 3.2.4 Structural Barriers

According to Hoicka et al. (2014), rates of participation in programs are considerably affected by the minimization of inconvenience, the credibility of the program delivery agent, the type of program delivery agent, and by the type of financial instrument offered to participants (Hoicka et al., 2014, p. 595).

*Payment Obligations*

As there is always a chance for homeowners to decide to sell their homes, they might doubt investing in energy efficiency. Often homeowners would have to get a loan to pay for the improvement process, and in case of selling the house they have to pay off their loan anyways. In this case, amassing debt can be a discouraging factor in participating in energy efficiency improvement programs.

In 2010, the Toronto Environment Office (TEO) in partnership with Ipsos Reid surveyed 500 homeowners in the City of Toronto to study Torontonians' reaction to a proposed low-interest loan program. While many of the participants supported this program, half of them said they would support a loan attached to the homeowner. Only one fourth of them favoured a loan attached to their property (Ipsos Reid, 2010). It is worth noting that only 7% of the total participants were planning to move out and sell their property. The reason why a large proportion of Toronto homeowners favour loans attached to homeowners compared to loans attached to properties, could be their uncertainty about how attaching this loan to their property could impact their property value and the marketability of their property. Indeed, homeowners' income levels and financial situations can significantly influence the way they respond to this question about their preferred form of payment obligation.

*Misplaced Incentives*

While incentives positively affect higher participation rates and result in verified improvements to the energy performance of houses (Hoicka et al., 2014), misplaced incentives are always an important barrier to participation in energy efficiency retrofits. Misplaced incentives occur when the economic benefits of the energy efficiency improvements, and/or the reward for undertaking it, doesn't accrue to the person who has financially invested in efficiency improvements. In Jaffe and Stavin (1994)'s term, this 'principle-agent' problem is a form of market failure that negatively affects consumers' interest in energy efficiency investments. A common example of misplaced incentive is retrofitting tenanted homes. Many scholars believe the reason behind lack of interest of landlords in energy efficiency improvements is lack of investment in tenanted stock due to landlords and tenants 'split-incentive' (Hope & Booth, 2014, p. 2). This problem is also known as the tenant/landlord dilemma. This dilemma happens when “a landlord and a tenant have difficulties in agreeing upon a common strategy for energy-efficiency improvement of a property” (Atmarson et al., 2013). There is a misplaced incentive, where tenants are responsible for paying the energy bills, and the landlord has the power to undertake energy efficiency refurbishment. In this case, there are few incentives for landlords to invest in energy efficiency. Even if they decide to retrofit their property, they will usually finance it by raising the rent, and this increase could be problematic for the tenants. Misplaced incentives are important barriers to undertaking energy efficiency upgrades and usually result in losing interest, postponing, or avoiding the program.

Last but not least, long and complicated processes with multiple stages to get the loan or receive the incentive often hinder participation in an energy efficiency retrofit program. Even for those who have participated in retrofit loan/incentive programs, there is a higher chance to opt out when the program has a long and complicated bureaucratic process.

# Chapter 4: Program Evaluation

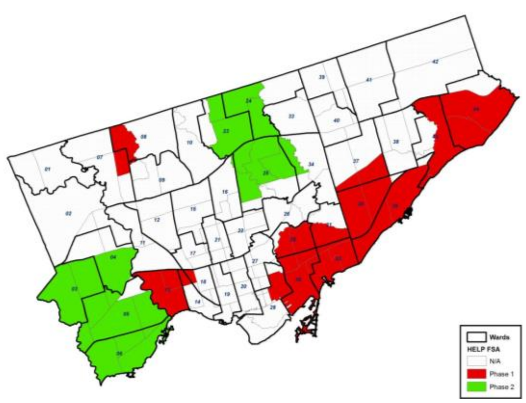
## 4.1 Overview of the Reviewed Home Energy Efficiency Retrofit Programs

4.1.1 The Home Energy Loan Program Background:

The Home Energy Loan Program (HELP) is a new financing tool that offers a low interest loan to homeowners who are willing to undertake energy Improvements. This program uses the Local Improvement Charges (LIC) to finance energy efficiency retrofits of residential properties. Local Improvement as defined by the Ministry of Municipal Affairs and Housing is "a project undertaken by a municipality that provides a benefit to properties in the vicinity, such as sidewalks and sewers" (MAH, 2015). HELP ties financing energy efficiency retrofits to Local Improvement Charges and raises funds to undertake energy efficiency improvements on private residential properties with owners' agreement to impose a special charge on the property indicated on the property tax bill. HELP is the very first program of its kind in Ontario. However, LIC-based home energy efficiency programs, such as PACE, have a relatively long history in the United States, specifically in California.

The Ministry of Municipal Affairs and Housing proposed an amendment to the Local Improvement Charges regulations under the Ontario Municipal Act, 2001 (O.Reg. 586/06) and the City of Toronto Act, 2006 (Government of Ontario, 2012 Cited in Dunsky, 2013). In October 2012, the amendment to provide funding to consenting homeowners interested in undertaking energy works on private property was enacted (Office of the Environmental Commissioner of Ontario, 2015). As Dunsky (2013) states: "The amendment allows municipalities to undertake works on private properties and enter to a voluntary contract with the property owner to recuperate the capital costs through the imposition of a special charge added to the property's tax assessment" (p. 14).

In July 2013, City Council unanimously approved a $20 million energy and water efficiency initiative for the residential sector and authorized the City staff to implement a 3-year pilot program geared towards the low-rise single family housing and multi-residential sectors. The program was launched and ready to accept applications in January 2014. As a pilot program, HELP was not available to all homes in The City of Toronto during the two phases of the program. The map below presents the eligible neighbourhoods in all three phases of the program. In the first phase of the program, launched in January 2014, 96,561 dwellings were eligible to participate. The second phase of the program added 67,915 more eligible dwellings in September 2014. Eventually, the program became available to all Torontonian homeowners in April 2015. The map below briefly represents the eligible neighbourhoods.




| Launch: January 2014 | |
|---|---|
| Black Creek | M3N |
| Beaches-Riverdale | M4E, M4L, M4M, M4J, M1N, M4C, M4K, M5A |
| High Park-Junction | M6P, M6S |
| South Scarborough | M1M, M1E, M1C, M1L, M1K |
| Total eligible dwellings = 96,561 | |

| Launch: September 2014 | |
|---|---|
| Central-South Etobicoke | M8V, M8W, M8Y, M8Z, M9A, M9B, M9C |
| Don Valley-Willowdale | M2K, M2L, M2M, M2N, M2P, M3B, M4N |
| Total eligible dwellings = 67,915 | |

**Phase 1** Phase 2

Figure 3: Retrieved from: The Home Energy Loan Program Interim Status Report, April, 2015

This three-year pilot program benefits from a funding of 20 million Dollars. It is led by the Environment and Energy division of The City of Toronto and has a target of retrofitting 1000 homes in Toronto by the end of the three-year period.

The HELP application process consists of five steps.

*Step1: Pre- Qualification*

Homeowners fill out a pre-application form. In this step, homeowners provide general information about their address, postal code, type of fuel, property type, mortgage lender information (if applicable), and their property assessment roll number (located on their tax bills). The City staff review the pre-application and provide the homeowner with a personalized letter and a form, if the homeowner's home is subject to a mortgage. Homeowners should secure the mortgage lender's consent before proceeding with the application.

*Step 2: Home Energy Assessment & Funding Request*

After completing the pre-application form and getting approved to proceed, homeowners will book what the program calls a *basement-to-attic-home energy assessment*. The assessment is not complementary, and the homeowner should pay the audit fee. The first audit costs $350 plus the applicable tax ($395). Enbridge, an independent natural gas distributing company, offers a $150 rebate on the first audit. Therefore, the total cost of the first audit would be around $245.50. The assessed home will be assigned an EnerGuide score, which is the energy efficiency rating system developed by the Natural Resource Canada. The EnerGuide score indicates the energy performance of the property. The energy advisors are not directly hired by the City, but they are qualified energy advisors. They provide a detailed report of the recommended improvements, the estimated energy savings, and the EnerGuide score upgrade. The homeowners will decide about the type and number of improvements and submit a funding request.

The maximum funding amount is 5% of the home value according to the Current Value Assessment (CVA). CVA estimates the market value of the property on a given date in an open market (City of Toronto, 2015). CVA differs from the actual sale value of the property. It is a standard system that evaluates the actual value of the home regardless of temporary market fluctuations. This system is mainly designed and developed for taxation purposes. The cost of borrowing plus an administrative charge of 2% will be applied to the total funding amount.

If homeowners meet the requirements to receive an incentive from the Enbridge Home Energy Conservation Program, they will automatically be enrolled for that program as well and will receive an incentive of up to $2000.

*Step 3: Property Owner Agreement*

Once the City approves the funding request, homeowners should sign the Property Owner Agreement (POA). POA is the funding agreement between the City and the homeowner. This agreement indicates the homeowners’ consent to impose a special charge, as a local improvement, on their property. After signing the POA, the City provides an initial disbursement of 10% of the project value to start the project.

*Step 4: Project Completion*

After completing the retrofit project, a post-retrofit assessment is conducted. The advisor verifies the improvements and assigns the post-retrofit EnerGuide score. The homeowner submits the project completion report to the City, which is a detailed report of the number and type of actual improvements along with the EnerGuide score upgrade and the project costs. The City will send a cheque for the balance of the funding. The following improvements can be financed by HELP (The City of Toronto, 2015):

- High efficiency furnace/boiler/central air conditioner
- High efficiency water heater
- Window or door replacement
- Air sealing (for example, weather stripping or caulking)
- Basement/attic/exterior wall insulation
- Toilet replacement
- Drain water heat recovery system
- Heat recovery/energy recovery ventilator

*Step 5: Repaying the Loan*

When submitting the funding request, the homeowners determine the loan term and the payment period. There are 11 payments per year that will be made through the City's pre-authorized payment plan. The homeowners can pay off the loan at any time without having to pay a penalty. It is important to note that the City doesn't function as a financial institution and does not offer this loan with the purpose of profit making. Therefore, the interest rates only reflect the cost of borrowing and opportunity costs. Table 2 below presents the loan terms and interest rates.

| Payment Term | Fixed Interest Rate |
|---|---|
| 5 Years | 2.5% |
| 10 Years | 3.75% |
| 15 Years | 4.25% |

Table 2: HELP's Interest Rates

### 4.1.2 The Enbridge Gas Home Energy Conservation Program

The Enbridge Gas Distribution Inc. is the largest gas distribution utility in Canada (Enbridge Inc., 2015). It generates, delivers, and distributes energy across North America. This company developed a three-year-demand side management plan called the 2012-2014 plan. The Home Energy Conservation program is one of the programs in the 2012-2014 plan that specifically incentivizes residential energy efficiency improvements. Unlike HELP that is specific to the City of Toronto, The Home Energy Conservation Program is offered in York Region, the City of Toronto (including the GTA), and some areas of Peel, Durham, Ottawa and Niagara. This research has collected and estimated the energy savings, GHG reductions, and participation rates of Enbridge (specifically in the Metro Toronto area). In this paper, where the full coverage of the Enbridge program is considered, the term "province-wide" is used, although the program doesn't fully cover the province of Ontario.

Enbridge offers up to a $2000 incentive to homeowners who retrofit their properties and increase the energy efficiency of their homes. There are four simple steps in this program. Homeowners that use natural gas as their primary energy source, have an active Enbridge account, and live in the areas that the program covers are eligible for the rebate. The eligible homeowners should book an energy audit. Enbridge pays $150 of the total $350 pre-retrofit energy audit cost. Homeowners who undertake a minimum of two of the following energy efficiency improvements are eligible for the post-retrofit rebate (Enbridge Gas, 2015):

- Attic insulation upgrade
- Basement wall insulation upgrade
- Wall insulation upgrade
- Air sealing (minimum 10%)
- Window replacement
- High efficiency space heating system installation (gas furnace/boiler)
- High efficiency water heating system installation (gas)
- Drain water heat recovery system installation
- Exposed Floor Insulation

Upon completion of the improvements, homeowners will receive $1600 for achieving 25%-49% natural gas saving minus the $500 for the full energy audit costs. To compensate the energy audit cost, an instant rebate of $150 will be offered for the first audit and $350 for the remainder of the audit cost will be reimbursed in the total remaining incentive amount that will yield a total incentive amount of $1450 (Enbridge, 2015). Homes that achieve a gas saving percent of 50% or more will receive $2000 incentives. They will qualify for an instant rebate of $150 for the pre-retrofit energy audit and $350 for the remainder of the audit cost. The total amount of the incentive, in this case, will be $1850 (Enbridge, 2015).

| Measures | % Improvement | Audit Incentive | Enbridge Incentive | Total Customer Cheque |
|---|---|---|---|---|
| Major Renovation | 50% > | $500.00 | $1,500 | $1,850 |
| Minor Renovation | 25% - 49% | $500 | $1,100 | $1,450 |

Table 3: The information above is provided by The Environment and Energy Division of The City of Toronto

### 4.1.3 R.E.E.P Home Assistance Program

R.E.E.P Green Solutions is a non-profit organization based in Waterloo, Ontario. In partnership with Greensavers, Kitchener Utilities, and Independent Electricity System Operator (IESO), they offer the Home Assistance Program (HAP) that supports energy efficiency upgrades. Depending on the heating and housing type, homeowners may be eligible for the following improvements without any cost (R.E.E.P, 2015):

- Energy saving light bulbs
- Energy efficient showerheads, faucet aerators, pipe wrap
- Electric power bars
- Draft proofing and insulation (Electric heated homes only)

Eligibility in this program depends on the income level of participants. The program is open to homeowners or residential tenants with an income level equal or lower than $32,212 for one individual, or those who receive financial support from the government (R.E.E.P, 2015). The program is also open to individuals who are enrolled in the Utility Low Income Energy Assistance Program (LEAP). R.E.E.P works with homeowners, residents, contractors, energy advisors, and local utilities. It connects residents with energy retrofit incentive programs and education and assistance providers. R.E.E.P also offers EnerGuide for Homes Evaluations to all residents of the Waterloo Region, regardless of their income level. Kitchener Utilities covers $60 of the cost of the pre-retrofit evaluation and $40 of the cost of the follow-up evaluation. According to R.E.E.P's annual report (2014), this non-profit organization has conducted a total of 14,000 EnerGuide home evaluations since 1999. Unlike the HELP and Enbridge Gas programs, R.E.E.P does not offer and implement the program on its own. It engages different stakeholders from local residents and students to utilities, contractors, and other non-profit organizations. Another important difference of R.E.E.P compared to HELP and Enbridge is the fact that this program focuses on electricity saving and does not finance deep retrofits.

### 4.2 Main Findings

4.2.1 Program Diffusion and Participation Rate

The majority of the retrofit projects were undertaken in neighbourhoods that were eligible in Phase 1 of the program. Among the 96,561 eligible dwellings in Phase 1, 26 of the projects were located in the Phase 1 neighbourhoods. Interestingly, among the total 67,915 eligible dwellings that were added in the second phase, only two homes were actually retrofitted and a total of 3 projects were completed when the program became available city-wide. This finding indicates that extending the scale of the program did not necessarily increase the number of retrofit projects undertaken.

R.E.E.P's annual report (2014) claims that this program completed 264 energy audits in 2012 and 3,585 home energy audits from April 2013–March 2014. R.E.E.P covers a population of approximately 568,500 individuals, which is equivalent to 203,930 households (Region of Waterloo, 2015). The Enbridge Gas Home Energy Conservation program (HEC), on the other hand, had a total of 1,649 participants in 2013 and 5,213 participants in 2014. HEC covers a population of 13,792,052. Indeed, the population statistics provided here do not present the exact number of eligible homes, but they gave an understanding of the scale of each program introduced in this paper, exhibited in Table 4.

| Program | Timeframe | Participation Number |
|---|---|---|
| **HELP** | Jan 2014-October 2015 | 74 |
| **Enbridge** | 2013 | 1,649 |
| | 2014 | 5,213 (province-wide) |
| | 2014 | 1,720 (Metro Toronto) |
| **R.E.E.P** | 2012 | 265 |
| | 2013 | 3584 |

Table 4: Participation numbers

### 4.2.2 HELP Marketing and Promotion

In the first step of the program, where applicants provide general information about their properties' condition, applicants are also asked about the way they found out about the program. Among the total 320 applicants in the first step of the program, 132 applicants stated that they were introduced to the program by City staff. Table 5 indicates that the most effective means of promotion was hearing about the program from the City staff members. Neighbours, friends, and family had a better impact on promoting the program, compared to energy advisors, home renovation companies, social media, and Enbridge Gas Inc. There are no further details about the "other" means of promotion.

| Means of promotion | Number of participants |
|---|---|
| City staff | 132 |
| Neighbours, friends, and family | 31 |
| Energy advisors | 18 |
| Home renovation companies | 10 |
| Enbridge Gas Inc. | 15 |
| Social media | 15 |
| Community groups | 8 |
| Other | 91 |
| Total | 320 |

Table 5: HELP promotional means

### 4.2.3 Building Vintage

All of the studied buildings were built between 1902 and 1978. The chart below illustrates the number of completed projects and the building vintages.

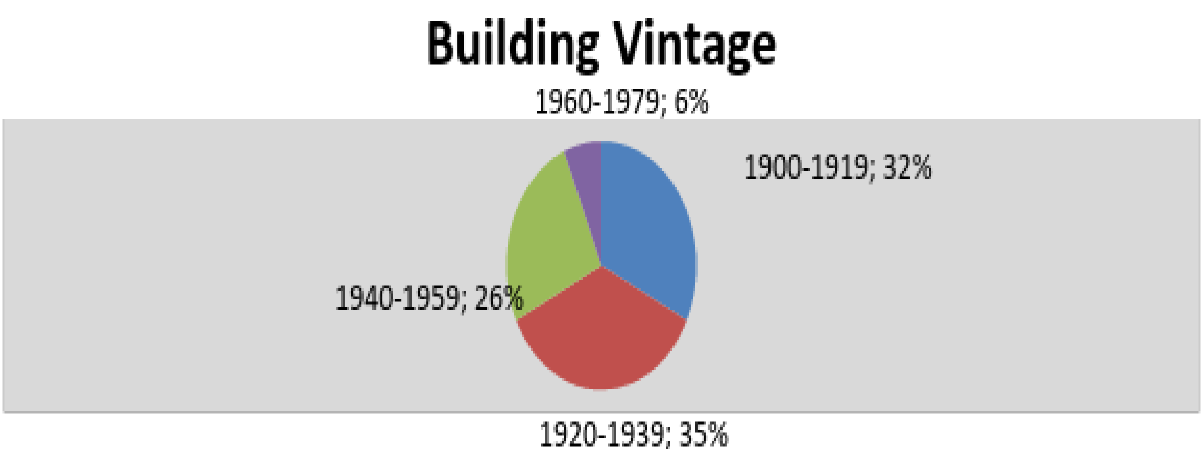



Figure 3: Building vintage

Analyzing the relationship between building vintage and natural gas consumption does not indicate a statistically meaningful relationship between the age of a building and its pre-retrofit natural gas consumption. The correlation analysis indicates a correlation as low as 0.13 between these two variables. Similar to the relation between natural gas consumption and building age, there is no significant or meaningful correlation between the level of electricity consumption and building vintage.

**4.3 Environmental Impact Analysis**

4.3.1 The EnerGuide Score

The EnerGuide rating system is used for new buildings, existing buildings, manufacturers, retailers, and some appliances. Having this label is mandatory for some appliances such as clothes dryers, freezers, and room air conditioners (NRCan, 2015). The EnerGuide for existing homes is a voluntary rating system with a range of 0 to 100 developed by the Natural Resource Canada that evaluates existing homes and indicates the energy performance of the home at the time of evaluation. The Figure 4 below explains the EnerGuide energy efficiency rating scores.


Figure 4: EnerGuide Rating Score

In Ontario, new buildings have a higher energy performance compared to other provinces. Under the 2012 Ontario Building Code, all new homes must be built to EnerGuide 80 standards (Hanes, 2012). In BC, new homes are required to achieve a score of at least 73 in the EnerGuide rating system. The Figure 5 shows the typical rating of residential buildings in Canada.

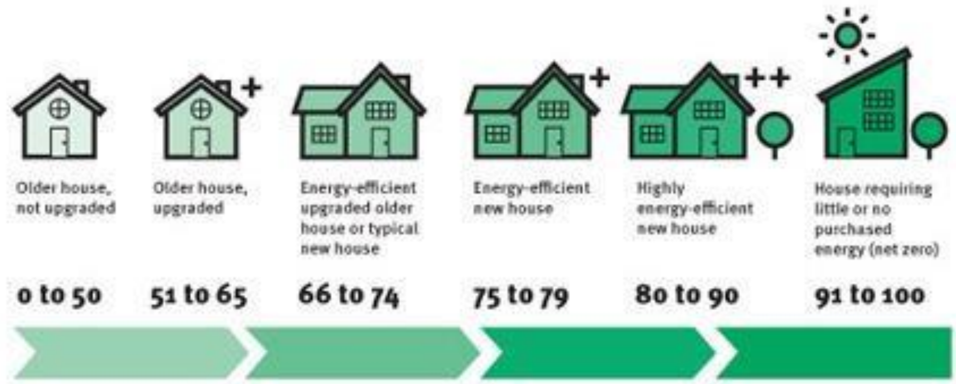



Figure 5: Retrieved from The City of Edmonton:

http://www.edmonton.ca/city_government/urban_planning_and_design/energuide-rating-system.aspx

The average pre-retrofit EnerGuide score of homeowners who participated in the HELP program is 51.7 and the average EnerGuide score upgrade of HELP projects is 12.96. The most energy efficient home that participated in HELP had a score of 66 and the least energy efficient home scored 19. The least efficient home of the program increased its score by 22 points and achieved the score of 41.

4.3.2 Energy Consumption

According to Statistics Canada, natural gas and electricity are the most common energy sources used for space heating by Canadian households (StatCan, 2007). In 2007, natural gas accounted for 58% and electricity for 30% of the total household energy use in Ontario. Overall, only 6% of Canadian households use oil as their primary energy source (StatCan, 2007). Due to high consumption of electricity and natural gas, this paper evaluates the impact of HELP in reducing natural gas and electricity consumption.

*Natural Gas Savings*

The average pre-retrofit natural gas consumption of HELP participants is 4317.89 (m3). There is only one project that used oil as its primary energy source before retrofitting. Indeed, that particular project did not consume any natural gas before retrofitting and increased its consumption after the completion of the retrofit activity. On average, HELP projects saved 1406.22 (m3) after undertaking the improvements. Of all 31 HELP projects, 30 had an average natural gas saving of 31%. However, the property that was primarily on oil increased its natural gas consumption by 3808.3 (m3). From a sustainability perspective, this increase in natural gas consumption is not necessarily negative. It is considered as an energy efficiency improvement because natural gas is a more sustainable fuel with lower levels of GHG emissions when compared with oil. Heating oil emits 69.34 Kg/Kj (161.3 pounds/Btu) of $CO_2$ while natural Gas emits 50.3009 Kg/Kj (117.0 pounds/Btu) of $CO_2$ (U.S Energy Information Administration, 2015) .

The Enbridge Gas data (2014) indicates that homeowners who participated in this program had an average natural gas saving of 1,334.87 (m3) in 2014. In other words, within 5213 HEC Enbridge clients, an average project saved 31% of natural gas.

For a deeper analysis, the 31 random Toronto-based HEC participants who didn't obtain a HELP loan were compared with the 31 evaluated HELP projects. The tables below illustrate a summary of the natural gas savings of HELP and Enbridge in different scales.

| **Random Sampling Comparative Analysis** | | | | | | |
|---|---|---|---|---|---|---|
| Program | Sample Size | Average pre-retrofit NG consumption | Average post-retrofit NG consumption | Average NG saving | Average NG saving % | Total NG Saving |
| Help | 31 | 4317.89 | 3034.43 | 1406.22 | 30.20% | 43593.00 |
| Enbridge | 31 | 5915.06 | 3524 | 2391 | 37% | 74116.00 |

Table 6: Random sampling comparative analysis

| **Total number of projects comparative analysis** | | | |
|---|---|---|---|
| Program | Sample Size | Average NG Saving (m3) per project | Average NG Saving % per project |
| HELP | 31 | 1406.22 | 30.20% |
| Enbridge (2013) | 1,649 | 1,181.94 | N/A |
| Enbridge (2014) | 5,213 | 1,334.87 | 31% |

Table 7

| **Program** | **Time Period** | **Estimated Net Annual NG Saving (m3)** |
|---|---|---|
| HELP (Toronto City-wide) | 14 months (2014-2015) | 104,060.28* |

| | | |
|---|---|---|
| R.E.E.P (Waterloo Region) | 12 months (April 2013- March 2014) | 59,934.00 |
| Enbridge Gas (Province-wide) | 12 months (2013) | 1,949,026.00 |
| Enbridge Gas (Province-wide) | 12 months (2014) | 5,914,881.00 |

Table 8: *$AverageNGsavedperproject \times totalnumberofprojects = 1406.22 \times 74 = 104{,}060.28$

There is not enough information about the average natural gas savings of R.E.E.P projects. However, according to the R.E.E.P Green Solutions 2013-2014 annual Report, R.E.E.P completed 3585 energy audits from March 2013 to April 2014 and saved 59,934 (m3) of natural gas in the Waterloo Region. Comparing this data with that of HELP indicates that, with an annual natural gas saving of 43593 (m3), HELP's gas savings was not as significant as that of R.E.E.P. That being said, HELP's gas savings resulted from 31 deep retrofit projects in a 14 month period, while there is no information about the total number of the actual energy retrofits undertaken by R.E.E.P participants. Assuming that all of the audited homes undertook some type of energy efficiency improvement, R.E.E.P's gas savings resulted from 3585 projects. This indicates that HELP's retrofits are deeper. In other words, we can conclude that, although HELP financed a smaller number of projects in a 14-month period, the depth of the retrofits and the average gas savings of HELP projects (1406.22 (m3)) has been higher than the estimated average gas savings of R.E.E.P ($\frac{totalNGsaving}{totalparticipants}$ =16.71 (m3)).

With total of 1649 participants, Enbridge was able to meet its target of saving 11,500,013 Cumulative Cubic Meters (CCM) of natural gas in the residential sector in 2013. According to the

Enbridge Gas 2013 Demand Side Management Report, Enbridge residential deep energy efficiency retrofits saved 38,980,521 (CCM) of natural gas, which is 339% higher than the programs' initial target (Enbridge, 2013). CCM is the measurement unit for natural gas savings over the life of an installed energy improvement measure. It is important to note that HEC covers a larger geographic area than HELP and, therefore, has a significantly higher participation rate.

The total natural gas savings amount associated with the Enbridge Home Energy Conservation (HEC) program in 2014 was 5,914,881.00 (m3) with a total of 5,213 participants throughout the province of Ontario. According to the Enbridge program advisor, around 33% of the participants in the Enbridge Home Energy Conservation program came from the Metro Toronto area, which yields an estimated natural gas saving of 1,951,910 (m3) within the boundaries of the City of Toronto. Assuming the similar average for all 52 completed HELP projects results an estimated natural gas saving of 73,123.44 (m3). The following table represents a comparison of HELP and Enbridge (2014) natural gas savings.

| **Program** | **Time Period** | **# of projects** | **Area** | **Estimated Natural Gas Saving (m3)** |
|---|---|---|---|---|
| **HELP** | 14 months (2014-2015) | 52 | Metro Toronto | 73,123.44 |
| **Enbridge** | 12 months (2014) | 1720 | Metro Toronto | 1,951,910 (Metro Toronto) |

Table 9: NG saving in Metro Toronto area

*Electricity Savings*

There is a statistically significant difference between the median and the average pre-retrofit and post-retrofit electricity consumption of HELP projects. The average pre-retrofit electricity consumption of all 31 projects is 11526.84 (kWh), while the median electricity consumption is 9303.00 (KWh). This significant difference is caused by including the outlier in the analysis. Electricity consumption of HELP projects ranges between 8700 and 9900 (KWh) with a minimum of 8760 (kWh) and a maximum of 9892.80 (KWh). That being said, there are three projects with electricity consumption of 14000-15000 (kWh) and only one project with an electricity consumption of 61290.8 (kWh). The highest electricity consumption level belongs to the property that used oil as its primary energy source. Excluding the oil-based home from the data analysis yields an average pre-retrofit consumption of 9868.04 (kWh) and an average savings of 258.73 (KWh). The median and the average are relatively close when the outlier is excluded. The median electricity saving of all 31 projects is 207.40 (KWh).

The Enbridge Gas Home Energy Conservation Program does not collect electricity consumption data from its customers. R.E.E.P, however, it states that it reduced electricity consumption by up to 2,004,282 (KWh) from April 2013 to March 2014 (R.E.E.P, 2014). The annual report indicates that there was a significant increase in the level of electricity savings of this program in 2013-2014, compared to 2012. Accordingly, the program saved 224,066 (KWh) in 2012. Going back to HELP, it can be seen that HELP saved 59631.70 (kWh) within the 14-month period of its activity.

| **Program** | **Annual Electricity Saving (KWh)** |
|---|---|
| **HELP** | 59,632 |
| **R.E.E.P (2012)** | 224,066 |
| **R.E.E.P (2013-2014)** | 2,004,282 |

Table 10: Annual Electricity Saving

The table above clearly indicates that HELP's achievements in terms of electricity savings is significantly lower than R.E.E.P. However, it is important to consider the concept of energy efficiency gap and the slow diffusion rate of pilot programs and innovative technologies. As R.E.E.P has been active since 1990s, it is a well-known program in the region and, therefore, has more participants. Furthermore, R.E.E.P focuses on electricity savings, serves a specific segment of the market, has a low average electricity savings, and includes a high number of participants.

Overall, as natural gas has a higher level of GHG emissions compared to electricity, the main focus of HELP is placed on the reduction of natural gas consumption. Additionally, as the majority of residential dwellings in Toronto use natural gas for space heating, natural gas consumption has a higher potential to be reduced by improving insulation and undertaking deep energy efficiency retrofits.

### 4.3.3 Energy Efficiency Improvements

The average number of improvements undertaken in HELP homes is 4.29 improvements. The most common type of improvement is window replacement with a total of 134 replaced windows undertaken by 21 of the HELP projects. Furnace/boiler system improvement and door replacement were undertaken in 18 of the projects, and 17 of the HELP participants selected air sealing. It is worth mentioning that HELP finances supplementary improvements that don't directly lead to energy saving but are necessary to do the actual energy improvement. Table 11 lists the six most common improvements undertaken by HELP clients.

| Type of Improvement | Number of Improvements |
|---|---|
| Window Replacement | 21 (total of 134 windows) |
| Furnace/Boiler System | 18 |
| Door | 18 |
| Air Sealing | 17 |
| Attic Insulation | 14 |
| Wall Insulation | 10 |

Table 11: Most common improvements

The average number of improvements per project for Enbridge was 2.3, considering that Enbridge only counts the actual improvements that directly lead to energy saving. Comparing HELP and Enbridge indicates that HELP had a better performance in encouraging homeowners to do more retrofit activities. However, as it supports supplementary works such as brick replacement and door frame replacement, the average stated here is higher than the actual number of energy saving improvements.

The correlation analysis of number of improvements and natural gas consumption saving (m3) indicates a correlation of 0.4 between the two variables. It can be inferred from this analysis that there is a chance of 40% that homes with a higher number of improvements save more on energy. Although this correlation is statistically meaningful, it is not significant. We can't conclude that the higher number of improvements in HELP projects necessarily yields a higher level of natural gas saving. There is no meaningful relationship between the number of improvements and electricity savings (Correlation of 0.22). The correlation analysis of number of improvements and EnerGuide score increase also confirms that there is not an absolute or statistically significant correlation between the level of energy savings and the number of undertaken improvements.

The random sampling comparative analysis with the sample size of 31 projects gives an average of 2.93 improvements for HEC Enbridge and 4.3 measures of improvement for HELP. Enbridge requires a minimum of 2 improvements to give an incentive to eligible homeowners, and the average of 2.93 shows that this program was able to encourage homeowners to do deeper retrofits. The table below lists the most common improvements in the sample size of 31 projects.

| **Type of Improvement** | **Help** | **Enbridge** |
|---|---|---|
| Window replacement | 21 of 31 | 5 of 31 |
| Air sealing | 17 of 31 | 30 of 31 |
| Furnace/boiler systems | 18 of 31 | 31 of 31 |

Table 12

### 4.3.4 Green House Gas Reduction

The Home Energy Loan Program did not set a specific target for Green House Gas emission reduction. Using the calculation method stated in Chapter 2, HELP projects saved 2.85 tonnes of GHG. In other words, an average HELP project saved 2.65 tonnes of GHG from natural gas savings and an average of 0.20 tonnes (equals to 201016.54 egCo2/m3) by reducing electricity consumption. The total amount of GHG avoided by financing home retrofitting through HELP in these 31 projects is 88.61 tonnes. Overall, 82.41 tonnes of GHG was avoided through natural gas reduction and a total of 6.2 tonnes of GHG were avoided by saving on electricity consumption by retrofitting 31 projects through HELP.

The R.E.E.P program claims an estimate of 32 tonnes of Co2 reduced in 2012 and a total of 400 tonnes of Co2 reduced in 2014. It is important to note that R.E.E.P used different emission factors for this calculation. Applying the emission factors used for HELP GHG reduction calculation results in 23 tonnes of avoided Co2 in 2012, 209 tonnes in 2013 from electricity saving, and around 113.31 tonnes of Co2 reduction by natural gas consumption reduction. The table below compares GHG reduction amounts resulted from natural gas saving in the three studied programs.

| **Program** | | **Avoided GHG from Natural Gas Saving*** |
|---|---|---|
| **HELP (Metro Toronto)** | | 82.41 |
| **R.E.E.P (2013 - Waterloo Region)** | | 113.31 |
| **Enbridge (2014)** | **Metro Toronto** | 3,690.33 |
| | **Province of Ontario** | 11,183 |

Table 13: *$Totalnaturalgasconsumption \times 1890.63 = avoidedgCo2/\mathrm{m3}$ => converted to tonnes

The avoided GHG calculation conducted on the sample of 31 projects clearly indicates that Enbridge's GHG saving was significantly higher than that of HELP. The random sampling comparative analysis results are summarized in table 14.

| **Random Sampling Comparative Analysis** | | |
|---|---|---|
| **Program** | **Sample Size** | **GHG avoided from NG saving** |
| HELP | 31 | 82.41 |
| Enbridge | 31 | 140.12 |

Table 14: Random sample's GHG emission reduction

### 4.4 Economic Impact Analysis

4.4.1 Energy Cost saving

The energy audit reports provide the total post-retrofit energy costs of all retrofitted projects, but there is no information about the energy costs of those projects before undertaking the retrofit activity. In order to calculate natural gas savings as a dollar amount, the cost of natural gas per unit was calculated by dividing total post-retrofit natural gas cost by total post-retrofit natural gas consumption (m3). Second, cost per unit was multiplied by the pre-retrofit natural gas consumption in order to estimate the pre-retrofit natural gas cost. Finally, the total pre-retrofit gas cost was deducted from the total post-retrofit gas costs and the total gas saving was calculated. The following formula indicates all three steps of this calculation. The same procedure was also used to estimate electricity saving.

$$cost\ of\ NG\ per\ unit(\$) = \frac{total\ postretrofit\ NG\ cost(\$)}{total\ post - retrofit\ consumption(m3)}$$

$$total\ preretrofit\ NG\ cost(\$) = NG\ cost\ per\ unit \times pre\ retrofit\ NG\ consumption(m3)$$

$$NG\ Saving\ (\$) = total\ preretrofit\ cost(\$) - total\ postretrofit\ cost(\$)$$

The average annual cost savings of natural gas and electricity are significantly different. The average annual natural gas savings for HELP projects is \$896.76, while the average annual electricity saving (excluding the outlier) is \$19.79. Including the outlier in this analysis increases the electricity saving to \$224.52 (while the median remains at \$22.18) and decreases the natural gas saving to $804.81. The table below presents a breakdown of the monthly and annual energy savings.

| Home Energy Loan Program Cost Savings (outlier excluded) | |
|---|---|
| Natural Gas Cost Saving | $896.76 |
| Electricity Cost Saving | $19.79 |
| Monthly Bill Saving | $76.38 |
| Average Annual Energy Cost Saving | $916.56 |

Table 15: HELP's projects cost saving

### 4.4.2 Cost-Benefit Analysis of HELP Projects

The cost benefit analysis is performed on the sample of 31 HELP projects. The NPV, IRR, ROI, and payback years for 31 HELP projects were calculated. It is important to note that I did not develop the formula to calculate the following metrics. An Excel template that was provided by the finance department of the Environment and Energy division of the City of Toronto was used to analyze the cost and benefits of HELP projects. Simply by entering the cost breakdown of HELP projects and filling the required fields in the Excel template, I was able to gather the following information. NPV, IRR, ROI are defined below:

| | |
|---|---|
| **Net Present Value (NPV)** | A method of capital budgeting in which the value of an investment is calculated as the total present value of all cash inflows and cash outflows minus the cost of the initial investment. If the net present value is positive, the return will be greater than that required by the capital markets and the investment should be considered. A negative net present value indicates that the investment should be rejected (p.333). |

| | |
|---|---|
| **Internal Rate of Return (IRR)** | An interest rate that gives a net present value of zero when applied to a projected cash flow of an asset, liability, or financial decision. This interest rate, where the present values of the cash inflows and outflows are equal, is the internal rate of return for a project under consideration, and the decision to adopt the project would depend on its size compared with the cost of capital (p.258). |
| **Return On Investment (ROI)** | An accounting ratio expressing the profit of an organization for an accounting period as a percentage of the capital employed. It is one of the most frequently used ratios for assessing the performance of organizations (p.425) |

Table 16: The information above is retrieved from the Oxford Dictionary of Finance and Banking (5th Edition)

The total amount of HELP loans offered to the 31 assessed HELP projects is $289,499. The average actual funding amount of HELP projects (excluding the administrative fees and costs of borrowing) is $14,036.74, which means energy improvement activities cost $14,036.74 for each HELP participant. The City's initial assumption was that, on-average, each retrofit project would cost approximately $10,000, while improvements turned out to cost more than what the City assumed. Including the cost of borrowing and the 2% administrative fee to the actual funding amount, yields an average LIC amount of $15,863.55 for each project. In other words, an average HELP participant pays back a total of $15,863.55 in the agreed period of time.

Assuming a 5% increase in electricity prices, a 3% increase in natural gas costs, and a discount rate of 2.95%, the estimated average NPV is $1,185 and the average payback period of HELP energy efficiency investments is 10 years. An average IRR of 10% and an average ROI of 273% are estimated for energy efficiency investments that are financed by HELP. The estimated average cost of HELP investments is $15,121, and the estimated average benefits of those investments is $23,256, which gives an estimated net result of $8,326.

The positive average NPV of $1,185 means that an average HELP project earns more income from investing in energy efficiency (through HELP) than gaining the discount rate or simply saving the invested money. To simplify, the average IRR of 9% means that an average HELP project is expected to generate a 9% rate of growth. Projects with a higher estimated IRR provide a better chance of an economically successful investment.

Generally, an ROI of 100% means that the generated benefits of an investment are twice its initial cost. Therefore, each dollar spent on energy efficiency improvements (through HELP) brought $2.40 of profit. The snapshot below represents the detailed cost benefit analysis of all 31 projects.

| Project | HELP Loan | Estimated NPV | Estimated IRR | Estimated ROI | Estimated Payback Years | Estimated Total Costs | Estimated Total Benefits | Estimated Net Result (Benefits - Costs) |
|---|---|---|---|---|---|---|---|---|
| 1 | $4,765 | $11,351 | 22% | 467% | 5 | $5,167 | $22,357 | $17,190 |
| 2 | $18,755 | $62 | 3% | 134% | 15 | $25,720 | $27,048 | $1,328 |
| 3 | $13,154 | $12,834 | 16% | 245% | 6 | $14,263 | $54,652 | $40,390 |
| 4 | $8,474 | $2,972 | 7% | 178% | 11 | $10,332 | $17,289 | $6,958 |
| 5 | $13,786 | -$10,170 | -8% | 34% | NA | $16,809 | $4,929 | -$11,879 |
| 6 | $10,222 | -$712 | 2% | 111% | 11 | $11,083 | $20,777 | $9,694 |
| 7 | $12,161 | $152 | 3% | 137% | 16 | $14,827 | $16,962 | $2,134 |
| 8 | $1,621 | $10,173 | 52% | 1008% | 2 | $1,757 | $16,328 | $14,571 |
| 9 | $2,788 | $14,516 | 44% | 859% | 2 | $3,023 | $23,998 | $20,975 |
| 10 | $14,872 | $13,259 | 11% | 262% | 9 | $16,125 | $39,240 | $23,115 |
| 11 | $7,281 | $3,984 | 8% | 216% | 11 | $7,895 | $15,886 | $7,991 |
| 12 | $15,624 | $6,885 | 7% | 198% | 12 | $19,050 | $31,239 | $12,189 |
| 13 | $7,499 | $2,107 | 9% | 148% | 6 | $9,143 | $33,906 | $24,764 |
| 14 | $29,103 | -$21,265 | -8% | 35% | NA | $31,556 | $10,717 | -$20,839 |
| 15 | $23,956 | -$1,513 | 2% | 127% | 17 | $25,975 | $30,988 | $5,012 |
| 16 | $10,806 | $153 | 3% | 137% | 16 | $13,175 | $15,064 | $1,889 |
| 17 | $23,943 | -$8,978 | -2% | 83% | NA | $25,961 | $20,458 | -$5,503 |
| 18 | $13,733 | -$8,978 | -2% | 83% | NA | $25,961 | $20,458 | -$5,503 |
| 19 | $14,488 | -$992 | 2% | 126% | 17 | $29,323 | $18,611 | -$10,712 |
| 20 | $10,000 | $7,932 | 10% | 247% | 10 | $10,843 | $24,903 | $14,060 |
| 21 | $15,564 | $6,374 | 7% | 194% | 12 | $25,254 | $30,580 | $5,326 |
| 22 | $16,903 | -$14,080 | -11% | 20% | NA | $18,326 | $3,771 | -$14,555 |
| 23 | $13,916 | $7,303 | 8% | 210% | 11 | $16,967 | $29,498 | $12,531 |
| 24 | $17,007 | $42,861 | 22% | 490% | 5 | $23,345 | $83,717 | $60,372 |
| 25 | $13,223 | -$9,196 | -9% | 37% | NA | $14,338 | $5,124 | -$9,214 |
| 26 | $18,228 | -$1,090 | 2% | 127% | 17 | $22,225 | $23,430 | $1,205 |
| 27 | $25,924 | $31,000 | 13% | 307% | 8 | $35,550 | $80,207 | $44,657 |
| 28 | $10,851 | $4,708 | 7% | 194% | 11 | $14,880 | $21,294 | $6,414 |
| 29 | $29,513 | -$15,182 | -4% | 64% | NA | $32,000 | $19,572 | -$12,428 |
| 30 | $5,451 | -$2,372 | -2% | 77% | NA | $5,910 | $4,292 | -$1,618 |
| 31 | $14,376 | $94,550 | 36% | 1097% | 4 | $17,527 | $158,013 | $140,486 |
| **Estimated Portfolio Average** | **$13,159** | **$1,185** | **9%** | **240%** | **10** | **$16,435** | **$22,735** | **$6,571** |

Table 17: The cost-benefit analysis

As can be seen in Table 16, there are 12 projects (out of 31) that had a negative NPV. Project 14, which has the lowest NPV (-21,265) undertook a relatively high number of improvements. This property replaced 10 windows, costing approximately $14,400 with an expected lifetime of 20 years for each. It also spent $7,340 on carpentry and $6,215 on wall insulation. This project had a lower level of pre-retrofit EnerGuide score, compared to other projects and increased the score from 34 to 41. Looking into this specific case indicates that, although this property made a relatively large investment in energy efficiency, spending $14,400 on windows did not significantly decrease energy consumption. In other words, window replacement is an expensive improvement, but does not have a big impact on energy cost reduction. Many energy advisors suggest that window replacement rarely provides a reasonable energy savings and similar or even higher energy reduction levels may be achievable by investing in other types of improvements like insulation (Beuerlein, 2010; Wallender, 2015). This specific case spent $6,215 on wall insulation with an expected lifetime of 30 years, which is 10 years more than that of windows and $8,185 cheaper than window replacement. That being said, unlike investment on wall insulation that has no effect on the appearance of the building, window replacement may be more appealing due to its aesthetic impact.

The cost-benefit analysis indicates that, while benefits outweighed the costs in most cases, in 29% of the cases (9 projects) costs were higher than the benefits. Interestingly, 8 out of those 9 projects undertook window replacement. In fact, there were other projects that invested in window replacement, but gained a higher level of benefits compared to the money that they spent. Project 27 replaced 17 windows, which is the highest number of window replacement among all 31 projects. Undertaking 8 different types of improvements, this property also had the highest number of retrofit activities. Table 17 compares project 27 (one of the highest benefits-costs) and project 14 (lowest benefits-costs) in greater detail.

| **Project number** | **14** | **27** |
|---|---|---|
| %NG Saved | 11.24% | 45% |
| % Elec. Saved | 1.44% | 39% |
| # of Replaced Windows | 10 | 17 |
| Cost of windows | $14,306 | $15,500 |
| Funding amount | $31,556 | $35500 |
| cost of borrowing + admin cost | $2452 | $9626 |
| Monthly payment | $574 | $215 |
| Incentive | $0 | $2,000 |
| Monthly Bill saving | $33 | $228 |
| Net Result | $-20839 | $44,657 |

Table 18

Although window replacement is not the most cost-effective type of improvement, project 27 clearly indicates that depending on the specific characteristics of the house, the efficiency level of the selected windows, and other types of undertaken improvements, window replacement can be a reasonably cost effective improvement. By conducting the above comparison, we can conclude that the investment failure and unprofitability of HELP projects may not be directly related to the program design and structure. Indeed, homeowners' decision-making and energy advisors' recommendations about the type of improvements can positively or negatively affect the NPV and profitability of the investments. As both the energy advisors and types of improvements are selected by the homeowners, HELP has no or little control over the cost effectiveness of the projects from the homeowners' point of view.

# Chapter 5: Discussion and Recommendations

## 5.1 Discussion

This research paper aims to answer the posed research questions by conducting an impact evaluation and an efficiency evaluation on the Home Energy Loan Program. This section reflects back to the research questions and tries to answer those questions by means of the main findings of this study.

*What is the magnitude of saved energy and reduced GHG emissions?*

Analyzing the data provided by the City of Toronto indicates that HELP projects had an average estimated natural gas saving of 1,406.22 (m3). Due to the existence of an outlier in the dataset, the median was also calculated. The calculated median for natural gas savings was 1265.1 (m3). The total natural gas savings of all 31 assessed projects was 43,593 (m3). Assuming that all 74 contracted projects completed their retrofit with a similar average natural gas savings, we can conclude that HELP would have a total natural gas saving of 104,060.28 (m3).

The electricity savings resulted from the undertaken energy efficiency improvements are not impressive. The results were an average electricity saving of 258.71 (kWh) with the outlier excluded and a median of 207.40 (kWh). Even though the outlier is excluded, there is a slight difference between the average and the median that impacts the statistical accuracy of the analysis. That being said, this analysis gives a good understanding of the magnitude of saved energy. On average, HELP projects reduced their natural gas consumption by 31% and decreased the electricity consumption level by about 2%.

To calculate the total energy savings of the HELP projects, the total natural gas savings of all 31 projects was converted from m3 to kWh by multiplying the total by 10.5. Then, the total natural gas saving (kWh) was added to the total electricity saving (kWh) and resulted in 517,358.20 (kWh).

Looking at GHG reduction statistics, it can be seen that HELP had an average GHG reduction of 2.85 tonnes with 2.65 tonnes resulting from natural gas savings and 0.20 from electricity savings. The total GHG reduction amount for the HELP retrofit projects was 88.61 tonnes. Assuming the same average for all 74 ongoing HELP projects will result in a total of approximately 211 tonnes of avoided Green House Gas emissions.

The EnerGuide score analysis indicates an average HELP project score of around 51-52 before undertaking any energy efficiency retrofits. According to the EnerGuide labeling scale in chapter 4, older homes with some energy efficiency upgrades score between 52 and 65. Adding the average 13 scores increase after completing the retrofit activity, HELP homes do not move to another level of energy efficiency. In other words, although homeowners invest in energy efficiency improvements, none of the evaluated projects is considered an “efficient” home after completing the improvements.

*Is HELP cost-effective from a homeowners’ perspective?*

The cost-benefit analysis conducted in this research indicates that 71% of the projects were cost-effective in that the benefits were higher than the costs and, therefore, the investments were profitable for homeowners from the economic perspective. The projects’ lifetime ranges between 15-30 years and, as can be seen in the analysis, the average payback period is 10 years. These projects can be considered economically acceptable for homeowners, however, the long payback periods may prevent homeowners from investing in energy efficiency through HELP. Homeowners may be uncertain about selling their property or may have a plan to move out before recouping the investment. Based on local improvement charges, the HELP program is hoping to overcome this barrier by attaching the loan to the property and transferring it to the new homeowner.

Out of the 31 projects, 12 had a negative NPV, which generally means that the investments are not economically acceptable and, therefore, should be avoided. That being said, going back to the non-energy benefits of energy efficiency improvements, it is understandable for a homeowner to undertake energy efficiency improvement despite the added costs. Of the 12 projects that had a negative NPV, had a positive internal rate of return (IRR).

Overall, it can be inferred from the analysis that receiving a low interest loan for energy efficiency retrofitting makes economic sense for homeowners. HELP's funding attracts homeowners who are considering energy retrofitting and receiving the loan eases the burden of associated with the capital intensity of energy efficiency retrofits. That being said, considering the long payback periods, there is no convincing evidence from HELP's portfolio analysis that this program attracts homeowners who are not planning to undertake energy retrofitting or promote deep energy efficiency retrofits among those who do not have any upcoming plan for such investments.

*Does HELP meet its initial target after the pilot period?*

Interestingly, HELP didn't set any specific target for energy savings and GHG reductions. The program initially estimated that an average energy retrofit costs approximately $10,000 and it targeted to retrofit 1000 homes in Toronto. Within 22 months from the date the program start in January 2014 to October 2015, the program has completed 52 projects and has 22 more projects in process. From 320 applicants who submitted the pre-application form, only 74 projects have actually completed the whole process. This analysis indicated that an average HELP project costs around $14,036.74, which is higher than the City's initial assumption. Assuming that the program moves forward with the same pace, it will complete around 121 retrofit projects by the end of the three-year pilot program. In that case, the program will result in a total natural gas savings of 170,152 (m3), electricity savings of 31,306 (kWh), and total GHG reductions of 345 tonnes with a total capital commitment of $1.7 million dollars. Given the fact that the allocated budget for the HELP program is 20 million dollars, it is clear that the program is far behind its target and can't achieve its initial goals in a three-year period.

To evaluate the program in the bigger picture, it is beneficial to assume the program meets its target of retrofitting 1000 homes. If an average home saves 1406.22 (m3) of natural gas and 258.73 (kWh) of electricity, retrofitting 1000 homes results in an estimate of 1,406,220 (m3) of natural gas, 258,730 (kWh) of electricity, and a total GHG saving of 2686 tonnes. Even if HELP retrofits 1000 homes in a three-year period, the total GHG reduction of this program would be 1004 tonnes lower than that of Enbridge.

*Did HELP encourage homeowners to do more and deeper energy efficiency improvements?*

The impact analysis indicates that HELP participants saved an average of 71.34 (m3) more than Enbridge HEC 2014 participants, and 224.29 (m3) more than HEC 2013 participants in natural gas. HELP's participants undertook an average of 4.3 improvements, while Enbridge customers undertook 2.3 improvements. This is an important finding as it indicates that offering the loan increased the quantity of the undertaken improvements. The most popular type of improvement among HELP clients was window replacement, which was chosen by around 68% of the clients. Windows generally have a shorter life span (15-20 years), higher upfront cost, and relatively low impact on the reduction of energy consumption. Hence, although the number of improvements in HELP projects is higher, the selected type of improvements and the resulted energy saving do not show deeper or better quality energy retrofits.

Comparing HELP and R.E.E.P is a bit challenging, as the programs are very different in their nature. As a natural gas distributing company, Enbridge doesn't track its participants' electricity savings. Therefore, this research used the electricity savings of R.E.E.P to get an understanding of HELP's performance in electricity savings. Unlike HELP that mainly focuses on natural gas savings, R.E.E.P's emphasis is placed on electricity savings and, hence, has a better performance in saving electricity. Looking at R.E.E.P's data indicates that this program was successful in engaging Waterloo residents in energy efficiency and energy conservation matters, and it helps us to look at the methods R.E.E.P used to attract and encourage homeowners to save energy. Basically, R.E.E.P focused on small-scale energy saving achievements, served a specific segment of the market, and invested in information and collaboration to encourage energy efficiency and conservation as a means to promote pro-environmental behaviour.

Overall, HELP indicated a slightly higher natural gas saving level compared to HEC when the average natural gas of all projects was calculated. However, the increase in natural gas savings is so low that it doesn't justify allocating a 20 million dollar budget. By introducing the LIC into residential energy efficiency retrofitting, the City of Toronto was hoping to see more interest in investing in energy efficiency retrofits. However, the impact evaluation doesn't demonstrate a meaningful increase in the depth or quality of energy efficiency retrofits. The random sampling comparative analysis clearly explains that HELP did not increase the depth and quality of the energy retrofits. The analysis also proves that the loan mainly encouraged homeowners to undertake more costly improvements like window replacement. While homeowners, through Enbridge, tend to save more energy to qualify for the higher interest rate. Interestingly, despite the fact that HELP offers the same HEC incentive, combining the loan and the incentive didn't increase energy savings and, surprisingly, decreased it.

*How effective is HELP in bridging the energy efficiency gap?*

The concept of energy efficiency gap refers to the gap between the technological and economic potential of energy efficiency technologies and the actual market behaviour. I identified market failures and non-market failures as the main causes of the energy efficiency gap. Government intervention in resolving the market failures, such as information externalities and environmental externalities, and unobserved costs is usually economically justified, while policies that address the market barriers are not (Jaffe & Stavins, 1994). This research aimed to determine if HELP played a role in overcoming the market barriers and bridging the energy efficiency gap.

The cost-benefit analysis conducted in this research proves the existence of an energy efficiency gap in Toronto in the sense that, although the majority of projects gained higher rate of benefits compared to the costs, engagement and participation in HELP is very low. HELP is designed in a way that can address some typical barriers, such as high upfront costs, that homeowners face when they want to invest in energy efficiency retrofitting. The program delivery agent is the City of Toronto; therefore, the source of information is trustworthy and the problem of lack of trust is somewhat resolved. There is no clear evidence of the role of HELP in addressing the information gap. The very low participation rate can, indeed, be explained by reflecting back to the concept of energy efficiency gap and the low diffusion pace of energy efficiency. That being said, there is no evidence that offering this LIC-based low interest loan gained homeowners' attention or increased their knowledge and interest about energy efficiency retrofitting.

The low participation rate, in my opinion, indicates that the low interest loan bridged the barrier of high upfront costs and low access to capital for homeowners who were willing to undertake energy efficiency retrofits anyways. The program may have increased their certainty about their decision and eased their financial challenges. However, the program seems to be unsuccessful in attracting homeowners who don't have any information and/or plans about retrofitting their property. The program design supports Wilson and Dowlatabadi's (2007) argument about eliminating immediate costs and how having both costs and benefits in the future makes decision-making about energy efficiency retrofitting easier. That being said, whether homeowners get a loan from the City to undertake energy improvement or simply pay the upfront cost by getting a line of credit, the uncertainty about the future of the energy market and fuel prices along with the uncertainty about the outcome of the retrofit activity still exist. The certified energy advisors prepare a detailed descriptive report of pre and post energy assessments; however, only homeowners who take the first step and pay the audit fee will have access to that information. For a homeowner with no plan for retrofitting, the barriers of uncertainty and lack of information clearly exist and HELP didn't find a chance to address those barriers.

The HELP program design also confirms Jaffe et al's (2004) argument about the heterogeneity of customers and the fact that an investment that is cost-effective for an average homeowner may be NPV negative for a portion of homeowners. The cost benefit analysis conducted in this paper clearly indicated that 11 of 31 homeowners gained a negative NPV from investing in energy efficiency retrofitting. In many cases, the incentive played a great role in turning a negative NPV into a positive one by balancing the costs and benefits of an investment.

As HELP targeted homeowners, no evidence of the misplaced incentive barrier was observed. Incentives offered by the IESO and Enbridge Gas targeted homeowners who undertook energy efficiency retrofits and it was a smart decision for HELP to offer the same incentives to homeowners who received a loan. In addition, the program's flexibility in financing type and the number of energy efficiency improvements is the strength of the program that somewhat addresses the barrier of consumers' heterogeneity of preferences.

The program's flexibility acts as a double-edged sword. On one hand, it provides homeowners with a customized retrofit plan and finances supplementary improvements as well. In some projects, HELP financed supplementary activities like concrete disposal and frame installation for basement insulation. These activities, indeed, do not have a direct impact on energy-use. But from the customer service point of view, financing these activities paves the road for more energy efficiency improvements. Without paying for those, homeowners may lose their interest in energy efficiency retrofitting. On the other hand, when HELP finances supplementary improvements, changes in the cost benefit ratio occur by increasing the costs without increasing the energy saving and energy cost savings.

Another addressed non-market failure barrier to energy efficiency is payment obligations. Using local Improvement Charges to finance energy efficiency, the City was hoping to address this barrier and increase homeowners' interest in energy efficiency retrofitting. However, the survey result elaborated in Chapter 3 indicates that the uncertainty about the marketability and resale value of the retrofitted properties concern homeowners and, hence, they tend to choose path dependency over obtaining the pilot LIC-based loan. As the most common improvement activity among HELP participants was window replacement, it can be concluded that the barrier of invisibility of energy efficiency retrofit still exists. Although other types of retrofit activities, such as insulation and basement insulation, may result in a higher energy saving amount, participants tend to invest in window replacement regardless of the high cost, low life span, and high payback period. The reason might be that homeowners assume a higher chance for window replacement to add to their properties' resale value and marketability compared to improvements that are invisible.

The most identified barrier to participation in HELP, as identified by clients and the program supervisor, is securing the mortgage lender consent. From 320 applicants who submitted the pre-application form, only 180 homeowners were qualified to proceed, primarily due to challenges in receiving consent from mortgage lenders. 80% of the HELP applicants have mortgages, and 1 in 2 applicants are not able to attain their mortgage lender's consent. The problem is that LIC is subject to a priority lien in favour of the City of Toronto, which subordinates the lenders' position for default-insured mortgages (City of Toronto, 2015). The Canadian Mortgage and Housing Corporation (CMHC) offers a refund equivalent to 10% of the homeowners' CMHC mortgage loan insurance premium if a property obtains a 5-score upgrade in its EnerGuide score. But when it comes to getting a loan from the City, CMHC doesn't insure any LIC areas on a given property. As a result, banks often reject default-insured, middle-moderate income homeowners. In addition, current mortgage underwriting is not flexible and doesn't reflect the savings and benefits of making an investment in energy efficiency (City of Toronto internal presentation, 2015).

Taking all of this into account, I am convinced that the HELP program was able to overcome the barrier of high upfront cost and limited access to capital by eliminating the immediate costs and postponing all costs and benefits to future. The program design and strong customer service also indicates that, once homeowners pass the first step of the program, they are in good hands and will be motivated to proceed. However, there is no convincing evidence that HELP is bridging the energy efficiency gap and empowering homeowners to retrofit their property.

### 5.2 Recommendations

5.2.1 Community-based Social Marketing

"The bottom line is that the owners of the buildings – the consumers of the technology – must want the change" (Brown & Vergragt, 2012, p.162).

This research observed a considerably low level of participation in the HELP program. HELP demonstrated a poor marketing and promotion performance. According to the program supervisor, the City allocated a very low budget for marketing and, therefore, the program is not well-known among Torontonians. If the City uses a portion of the 20 million dollar budget (that is allocated for energy retrofitting) for marketing purposes, it will have a better chance of attracting more participants and, therefore, have a better performance. Creating sustainable cities requires behavioural change. To encourage pro-environmental behaviour (behaviour that has a minimum disturbing impact on the environment), many countries like Germany use community-based social marketing (CBSM). CBSM is based on the idea that community level initiatives that focus on removing the barriers to an activity and simultaneously enhancing the activity's benefits are the most effective strategies to influence behaviors (McKenzie-Mohr et al., 2011).

A great example of a community-based activity that encourages pro-environmental behaviour is Project Neutral. Project Neutral is a community-based organization that brings community members together to talk about environmental issues in response to climate change. By engaging neighbourhood leaders, benchmarking household GHG emissions and tracking progress, comparing community members in terms of their effort, and holding events and meetings, they engage homeowners and residents, raise awareness, and promote energy conservation and other types of pro-environmental behaviour. Through Project Neutral, homeowners can obtain free in-home energy displays to see real time energy costs and free energy saving kits to reduce hot water costs. In addition, involving children in energy efficiency and informing them about the importance of saving energy acts as an inexpensive means of marketing.

HELP can be promoted at schools. Children can be provided with a take-home assessment assignment and can work with their parents on assessing their energy use. In this way, not only will they learn about the HELP program, but they will also become attracted to other means of energy savings that do not necessarily require obtaining a loan (changing lights bulbs, turning off the lights when leaving, decreasing the indoor temperature, etc.). CPS Energy designed a simple online do-it-yourself energy assessment questionnaire (Visit http://cps.energysavvy.com). This questionnaire is so simple that children can easily complete it with their parents' and/or teachers' guidance.

### 5.2.2 Conducting a Market Study

The low level of participation in the HELP program could be due to an information gap existing between homeowners and the LIC-based low interest loan. Although the LIC-based system in the United States is successful in boosting participation and engaging homeowners, in Toronto, there is not much information about the green home market. Therefore, homeowners are uncertain of the impact of LIC on the resale value of their properties. In other words, homeowners are not sure how attaching the loan to the property and "greening" their property impacts the marketability of their homes. While in the states, the PACE program finances solar panel installation, and homeowners can generate income from installing renewable energy systems. In addition, going back to the problem of the invisibility of energy, financing energy efficiency and solar panel installation makes the improvements visible to the homeowner and the potential buyer. Moreover, there is already a green home market in many states (e.g California), and homeowners tend to associate a lower level of risk to obtaining an LIC-based loan. To overcome this barrier, a market study could be done to understand whether there is a market for green and net zero homes in Toronto; and if there is, how the market can be extended. The study can also evaluate the impact of attaching the LIC loan on the marketability of these homes by conducting experimental studies on MLS and/or launching surveys and focus groups. Involving real estate agents can play a significant role in learning how the green building market in the residential sector can be created and/or expanded, as they have a deep understanding of homebuyers' motivations (Brown & Vergragt, 2012).

### 5.2.3 Mandating Home Energy Rating Disclosures

Over 30 jurisdictions around the world have required home energy rating and disclosure in Europe, United States (Berkeley, California), and Australia (MOE, 2015). All EU members, for instance, have mandated home energy rating at the time of listing. Recent studies show that a one-level rating increase in a home's rating increases resale value by 2% to 8% (MOE, 2015). If the City of Toronto requires home energy labelling for the existing building stock and mandates disclosing the score on MLS when the home is listed for sale, chances are that buyers will tend to search for more efficient homes. In this way, the City can create a market for energy efficiency and green buildings and, therefore, can attract homeowners to invest in energy efficient retrofitting before selling their properties.

### 5.2.4 Program Structure Modification

As explained earlier, the most critical challenges that homeowners face to participate in LIC-based programs like HELP is securing a mortgage lenders' consent and the existence of a priority lien in favour of the City of Toronto. A more recent financing idea is called 'On-bill recovery'. This financing mechanism is similar to LIC-based programs, but attaches the loan on the utility bills instead of the property. In other words, the payment obligation is still on the property, but the lender is a utility company and the repayment is in the form of a surcharge on the utility bill (Brown & Vergragt, 2012). This financing mechanism solves the problem of the priority lien and removes the barrier to obtain the mortgage lenders' consent. As the bill-recovery format is offered by utilities, the HELP program could not be offered by the City. Therefore, the bill-recovery based program would be a totally new program. The New York State Research and Development Authority is currently offering an On-bill recovery financing program to homeowners who are willing to install solar panels on their property (See NYSERDA On-Bill Recovery Program).

Returning briefly to the R.E.E.P program design, it can be seen that this program had a significantly lower average energy saving. R.E.E.P mainly offers low-cost or free energy efficient appliances (such as energy saving light bulbs, efficient showerheads, faucet aerators, etc.). As it only targets a specific segment of the market, it designed the program according to their needs and interests and had a high participation rate.

Market segmentation by financial instrument is a strategy suggested by Stern (1986). This strategy seems to be an effective way to address heterogeneity of preferences. However, there is little knowledge about defining different segments of the market and how to incentivize them. Hence, to get a better understanding of how market segmentation can increase participation, further research is required (Hoicka et al., 2014). With respect to market segmentation, HELP has a great opportunity to identify the main segment of the market that it has currently served. By conducting a survey and focus groups studies, the City can learn about the income levels, needs, preferences, interests, and concerns of the majority of the participants and identify a target population and focus on attracting that specific group to participate in the program. The main findings of this research supports Gamtessa (2013)'s argument about the possibility of boosting participation by targeting the low-income homeowners and increasing the amount of the incentive.

Last but not least, a major limitation of this program is that it does not set clear targets and objectives. There are no GHG and energy reduction targets; nor is there a set job creation target. Without having set targets, evaluating the program's performance is a daunting task. If the City's purpose is reducing energy consumption, it can collaborate with utilities and design a new On-bill recovery financing tool, invest in energy conservation and behavioural change, and mandate energy efficiency labelling.

## Chapter 6: Conclusion:

HELP is basically assisting homeowners who are already interested in retrofitting their property. Through HELP, the barrier of the high upfront cost is resolved, and homeowners can initiate their retrofit activity without paying a penny in advance. The main challenge, however, is to involve those who don't care about mitigating 'the climate of concern' and do not show any interest in terms like conserving energy, saving the planet, reducing pollution, and what is called pro-environmental behaviour. Looking at the impact analysis, there is neither any evidence that indicates attaching the loan to the property increased homeowners' interest in energy efficiency retrofitting, nor is there any sign that offering a low interest loan boosts participation. The natural gas and electricity saving calculations show that homeowners who used HELP did not necessarily undertake deeper energy efficiency improvements. They rather invested in window replacement, which is a more expensive form of improvement with a shorter life span and lower level of energy savings.

Comparing HELP with Enbridge, HEC, and the R.E.E.P Home Assistance Program indicated that the Home Energy Loan Program had a very low participation level and was not able to increase the depth and quality of the undertaken retrofits. The R.E.E.P program demonstrated a lower level of energy savings per capita but a high level of participation. As participation in R.E.E.P was much higher that of HELP, R.E.E.P demonstrated a higher level of total annual energy savings.

The conducted impact analysis offered detailed information about the magnitude of energy savings and GHG reduction associated with the HELP projects. The cost-benefit analysis conducted on 31 HELP projects indicated that, in the majority of projects, benefits outweighed the costs, but the payback periods were relatively long. A negative NPV, more costs, and fewer benefits were observed in a portion of the projects. This phenomenon was due to the selected type of improvements, paying for supplementary renovation and improvement activities that did not lead to energy savings, and the specific characteristics of the properties. In fact, this finding supports Jaffe et al's (2004) argument about the heterogeneity of customers and the fact that a well-designed program can be cost-effective for most, but ineffective for a portion of the target population (Jaffe et al, 2004).

In this investigation, the aim was to assess the impact of HELP on homeowners' decision making with respect to the depth and quality of energy efficiency retrofitting. The paper also tried to determine the role of offering the LIC-based HELP program in overcoming the energy efficiency gap. Taken together, the findings of this research don't demonstrate an effective or influential role for HELP in bridging the energy efficiency gap. The paper also enhanced my knowledge of the role of marketing and promotional investments and expanded my understanding of the methods of influencing homeowners to undertake energy efficiency retrofits and addressing the explained non-market failure barriers of home energy efficiency improvement.

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